New Scientist

WEEKLY 30 December 2023

PREVIEW OF 2024
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ARTIFICIAL UTERUSES FOR HUMANS
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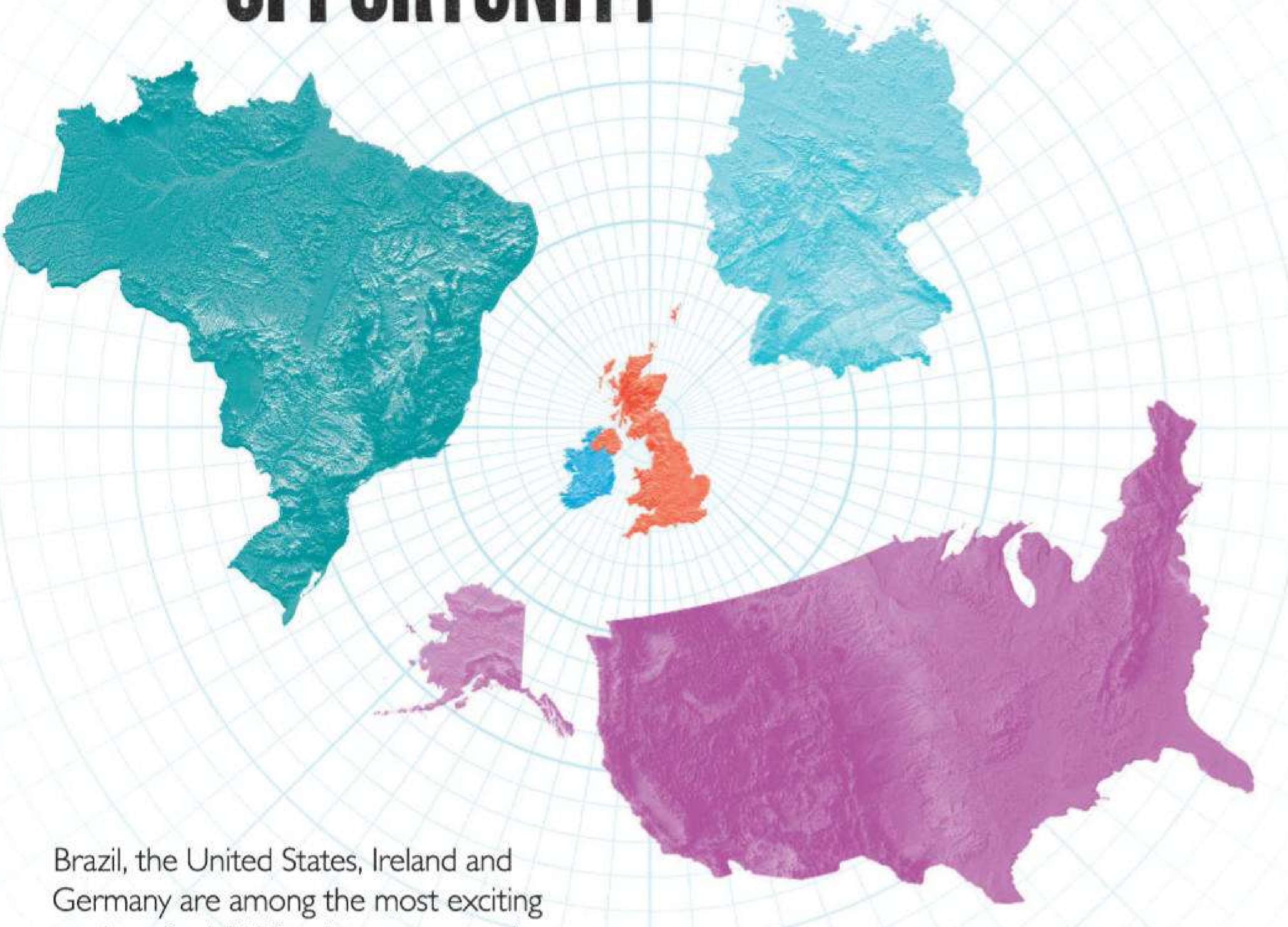

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Virtual event

The dark side of the universe

Hear cosmologist Katherine Freese recount stories from her book *The Cosmic Cocktail: Three parts dark matter*, from historic discoveries to the deluge of data today from underground labs, space satellites and particle accelerators. Learn whether we are close to solving the mystery of what glues galaxies together at this online talk at 7pm EST/12am GMT on 7 February.

newscientist.com/events

Tour

Tasmania's flora, fauna and geology

The Australian island of Tasmania boasts golden beaches, misty mountains and lonely patches of wilderness. Join biologist and conservationist Martin Cohen in seeking out Tasmanian devils, platypuses and fairy penguins. Wander among ancient geology and discover the island's Indigenous cultures. This 12-day tour begins on 20 February and tickets cost £4595.

newscientist.com/tours

Podcast

Weekly

The team discuss whether the climate deal agreed at COP28 is actually "historic". Hear about an AI mathematician built by Google's DeepMind and an unusual trick that seals use to keep warm. Find out how stress causes a disturbed night's sleep. Plus, the mystery of how a didgeridoo gives rise to such a unique sound has been solved.

newscientist.com/nspod

DAVE WATTS/ALAMY

Diving for grubs Spot platypuses on a nature lover's tour of Tasmania

MARK WARD (CC BY-SA 3.0)

DEAP detector Is the long search for dark matter coming to an end?

Video

Rewilding the Thames

The Zoological Society of London is restoring seagrass meadows in the UK's Thames estuary to create habitats for fish such as seahorses and sharks – and to improve water quality. The group is trying out different planting techniques in research beds to better understand the effects that sediment type, temperature, light, current and wave energies have on the plants.

youtube.com/newscientist

Newsletter

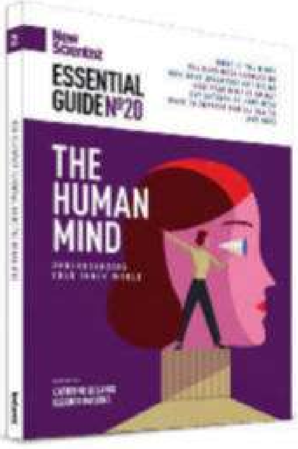
Wild Wild Life

Why is time spent outside in the wild or in gardens so good for you? Penny Sarchet looks at the breadth of evidence, including one study that found just looking at plants alters brain activity and reduces stress, anger and sadness. Find out how to make the most of these natural health benefits in the coming year.

newscientist.com/wild-wild-life

Newsletter

> **"How can I explain the feeling that I get when listening to a robin singing on a cold, dark day?"**



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What's past is prologue

2023's biggest stories will continue next year – but changes are on the horizon

AS WE close out 2023, what awaits us in 2024? As any sensible *New Scientist* reader knows, the division of time into years is a fairly arbitrary business, marking only that Earth has completed a full orbit around the sun (yes, OK, give or take 0.256363004 days, pipe down there at the back please). As such, many of the big stories of this year, such as the rise of artificial intelligence and the growing danger of climate change, will remain the big stories of the next.

Yet it is hard not to imbue a new year with new significance. In particular, 2024 looks set to be the year of the moon. An extraordinary armada of uncrewed probes and perhaps even crewed spacecraft will be headed to our orbiting companion (see page 17), marking what will probably be the most exciting period of lunar exploration since Neil Armstrong and Buzz Aldrin first touched down in 1969. With countries around the world promising big plans for the moon, could this be the start of a new space age?

Back here on Earth, we could also see the dawning of a new age – or at least a slightly old age could finally become official. After years of wrangling, researchers will vote on whether to declare 1950 as the start of the Anthropocene, a new geological epoch shaped by humankind (see page 15).

> "With countries promising big plans for the moon, could this be the start of a new space age?"

Such a declaration won't be the only event that will focus our minds on humanity's influence on the planet. Despite 2023 breaking heat records around the world, making it probably the hottest year ever recorded, 2024 is waiting in the wings to smash those records once again. While it is the El Niño weather pattern that keeps pushing us over the edge (see page 10), we wouldn't be standing on the precipice were it not for our global greenhouse gas emissions.

With countries at the COP28 summit having agreed to transition away from fossil fuels, will we really see action on ditching oil and gas before COP29 in November 2024 (see page 11)? We can only hope – and that really would make 2024 worth marking. ▮

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Jessica Comi (left) and MSF surgeon Dr Federica Lezzi extract a bullet from a patient shot just above the knee during fighting in the Sudanese capital. Bashair hospital, Khartoum, 13 May. Photograph © Ala Kheir/MSF

JESSICA COMI IS AN OPERATING THEATRE NURSE WHO WORKED FOR MSF IN KHARTOUM, SUDAN.

"We arrived in Khartoum on a Monday and started operating at noon the following day. The first week was incredibly challenging.

Every time we heard explosions, we got ready for a mass casualty incident – a situation where lots of wounded people arrive at the same time. You never know if it will be 20 or 40 or 100 patients. One day, 127 patients arrived in a short space of time after a series of explosions.

Very quickly we were inundated with wounded men, women and children. Seventeen people were dead on arrival. The emergency room was full, the two operating theatres were full. In one theatre, we were trying to manage the most complex cases; in the second, we were working on cases that were a bit less complicated. That day, we ran the operating theatres until four or five in the morning. We worked non-stop.

War surgery is complicated. Working with wounded patients brings a lot of challenges and, if you aren't used to doing this type of surgery, it can be especially difficult. You need to know the potential risk for a patient if they are not treated immediately – risks such as infections or losing a limb or haemorrhaging. Bullets and shrapnel are dirty and they create massive wounds, so in a war zone you treat every single wound as already infected. These injuries are complex and you need to act quickly. Our team was experienced and that expertise made a big difference.

Depending on the kind of wound, some patients need multiple surgeries and can take many days to recover. Others may need even longer treatment – taking weeks or sometimes months.

As the conflict continued and more people heard that the hospital was open, we started to see more patients, particularly women and children.

I have worked a lot in war zones, and this was probably my most challenging assignment. But it was very special how the team worked through the challenges together. You could feel that we were all working for one reason – and that was to save lives."

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NASA/JPL-CALTECH/GREGORY M. WAIGAND

1

Space exploration

Destination Europa

NASA's Europa Clipper mission is due to launch in October 2024 and head towards Jupiter's moon Europa, where it will hunt for signs that this icy satellite could be suitable for life. The spacecraft won't orbit Europa when it arrives in 2030 – instead, it will loop around Jupiter in a way that will allow it to repeatedly zoom past the moon at distances as close as 25 kilometres from its surface.

"We're going to get this really comprehensive assessment of what Europa is like," says Jennifer Scully at NASA's Jet Propulsion Laboratory in California.

Of the moon's many mysteries, perhaps the most important is the structure of its internal ocean and whether it could be habitable. While Clipper won't be able to look for life itself, it will set the stage for future missions that could. ▮

Weight loss

A new era of obesity treatments

Ozempic and Wegovy made headlines in 2023, but a more potent weight-loss drug could reach people in 2024 – with more on the horizon, reports **Clare Wilson**

23
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A weekly shot to lose weight
with coaching, care, and healthy lifestyle changes to make it last.
ro.co/shot
ro

New weight-loss drugs may ease shortages of Ozempic (below) and bypass the need to inject (left)

UPPER: REUTERS/GEORGE FREY; LOWER: RICHARD LEVINE/ALAMY

2

IT MAY feel like there has been a stream of stories about drugs used for weight loss in 2023, but get ready for double helpings in 2024. A more potent fat-busting injection will probably enter clinics and we will see further trial results for a smorgasbord of treatments in the pipeline.

Semaglutide, possibly the most talked-about medicine of 2023, was developed to treat diabetes and sold as the self-injectable Ozempic. It works by mimicking the action of a gut hormone called GLP-1. Normally pumped out by the body after eating, this makes us feel full, quells appetite and boosts the release of insulin, a hormone involved in regulating blood sugar.

Since another injectable version of semaglutide called Wegovy was launched for weight loss in people without diabetes in the US in 2021, and later in parts of Europe, demand for both soared. As the maker of these drugs, Danish firm Novo Nordisk, couldn't keep up, supplies ran short in the US and launches were delayed elsewhere, sparking a glut of headlines in 2023.

In 2024, however, a recently approved weight-loss drug called Zepbound (tirzepatide) will probably become widely used in the US, and elsewhere further down the line. This works by mimicking not only GLP-1, but also another gut hormone called GIP. Zepbound's arrival may ease supply shortages of the existing drugs – and it won't hurt that its US price has been set at several hundred dollars per month less than Wegovy.

While Zepbound and Wegovy haven't been compared in head-to-head trials, separate studies comparing them with a placebo suggest that the former could be superior – helping people lose 21 per cent of their body weight compared with 15 per cent. "The drugs are getting more powerful," says Daniel Drucker at the University of Toronto in Canada.

Another access issue has been the reluctance of US health insurers to fund weight-loss drugs, but the number of employer-based insurance providers that plan to cover this medicine class is set to rise to 43 per cent in 2024, up from 25 per cent in 2023, according to a recent survey. "I would hope that increased numbers of medicines will translate into more competition, improved access and less expensive medicines," says Drucker.

Zepbound aside, other weight-loss drug candidates on the more distant horizon might prove to be more effective still. GLP-1 and GIP aren't the only hormones released after eating. Others include PYY, also made by the gut, as well as glucagon and amylin, produced by the pancreas. In 2024 and beyond, we will learn more about the relative effectiveness of medicines that mimic various combinations of these hormones. They include an injection that contains both semaglutide and an analogue of amylin, one that mimics GLP-1 and glucagon, and another that does this for three hormones – GLP-1, GIP and glucagon – which has earned it the nickname "triple G".

Yet more progress could come with possible pill versions of injectable weight-loss drugs, which some people would prefer. Final-stage trial results are due in 2024 for an oral form of Wegovy for those without diabetes.

"We're only just starting with the innovation," says Drucker. ▮

Astronomy

Giant telescope will take incredible pictures of the night sky

Alex Wilkins

THE Vera C. Rubin Observatory is about to begin its mission to scan the entire southern sky every three nights for nearly a decade. These images will form the Legacy Survey of Space and Time, transforming our view of any object that twinkles or changes in the night sky.

"I think people will be amazed at just the sheer number of stars and galaxies that are in these images," says Keith Bechtol at the Vera C. Rubin Observatory.

The facility is built on Chile's Cerro Pachón mountain and houses the Simonyi Survey Telescope. The telescope's systems have already undergone extensive testing over the past several years. These include cooling equipment that will keep the camera at -100°C (-150°F), powerful motors that are able to point the approximately 300-tonne telescope anywhere in under 4 seconds (in order to capture fast-changing objects) and computers capable of handling the more than 15 terabytes of data that will be produced each night.

"Taking these very deep, high-quality images of the night sky very rapidly stresses all of our technology," says Bechtol.

Once each system has been carefully checked, Bechtol and his colleagues will begin the commissioning phase in July, when they will try out the telescope's picture-taking abilities with a smaller test camera rather than its 3.2-gigapixel main camera. "Even though it's only about 5 per cent of the size of the full camera, its ability to map the sky is comparable to many existing state-of-the-art telescopes," says Bechtol.

The first images taken by this camera will be intentionally blurry, so that Bechtol and his team can learn how to properly focus the telescope's optics. Once they are confident the telescope is performing well, they will take focused photos of high enough quality that astronomers can start using them for research, though there isn't a definitive date for when this will happen, says Bechtol.

Around August, the researchers will install the full-sized camera, which they plan to start taking pictures with in December. These images will be unlike those taken from any other telescope, says Bechtol. Scientists will be hit with a torrent of astronomical data almost immediately.

> "PEOPLE WILL BE AMAZED AT JUST THE SHEER NUMBER OF STARS AND GALAXIES IN THESE IMAGES"

"The quality of the data, its variety and its size and the data rate – astronomers have never dealt with that before," says Hiranya Peiris at the University of Cambridge.

Assuming that astronomers aren't completely overwhelmed, we could start learning new things about the universe right away, she says, just as the James Webb Space Telescope quickly began making discoveries when it started operations in 2022.

"Once it starts taking data, then for discoveries I expect it to be pretty rapid, just because it opens up this new discovery space that's never been explored before," says Peiris. ▮

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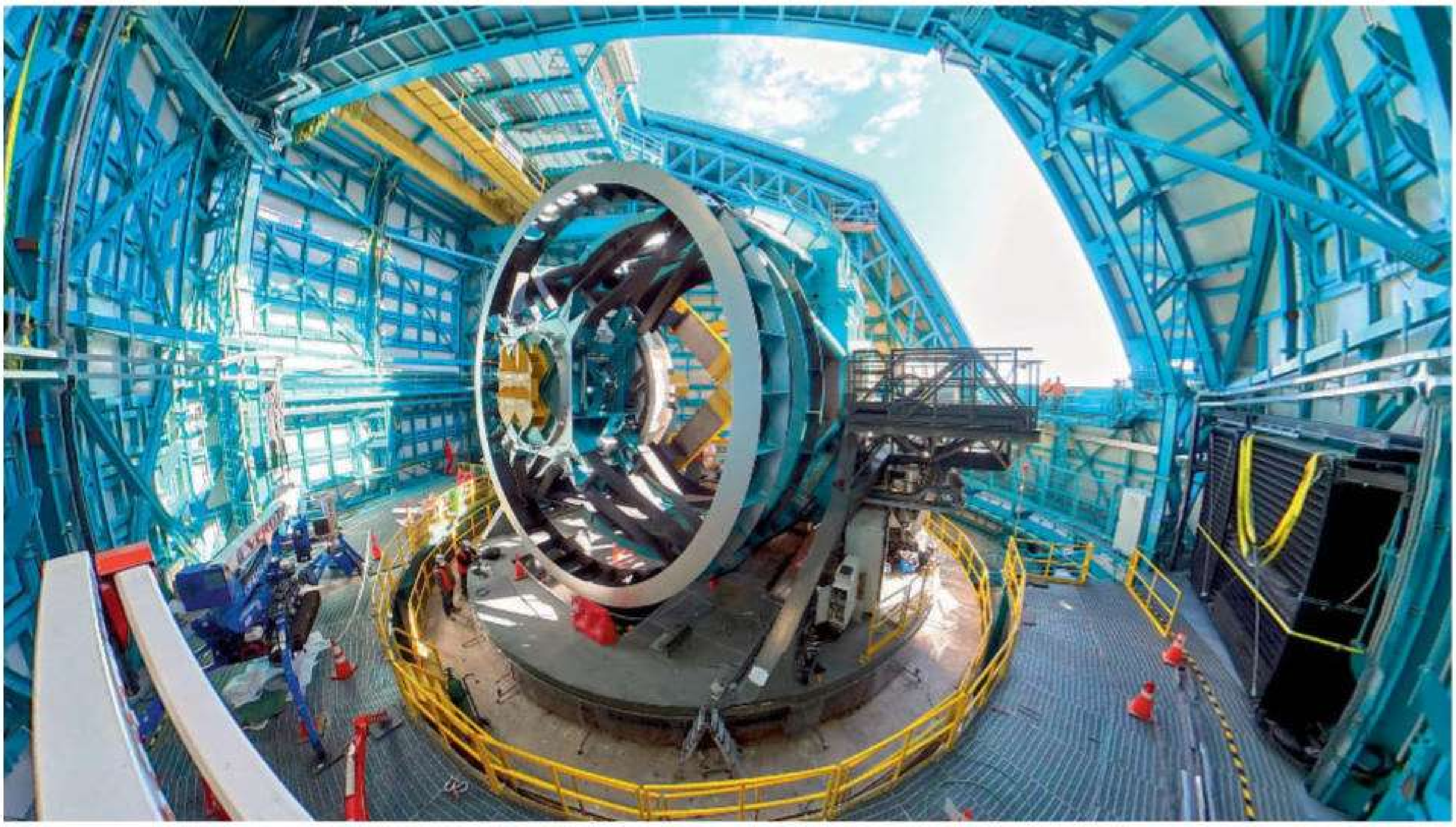

H. STOCKEBRAND/RUBINOBS/NSF/AURA

A wide-angle view of the Simonyi Survey Telescope in Chile

Climate change

Think 2023 was hot? Meet 2024

The elements that conspired to make 2023 so unusually warm are likely to push the dial even further next year, says **James Dinneen**

ANDER GILLENEA/AFP VIA GETTY IMAGES

An August drought in Villanueva, Spain, was one of many extreme weather events in 2023

4

THE past year was the hottest on record, but 2023 is unlikely to hold that dubious honour for long. 2024 is expected to be even hotter, as the El Niño climate pattern in the Pacific Ocean reaches its full strength on top of warming driven by greenhouse gases. "We've never had a big El Niño like this on the background of global warming," says Adam Scaife at the Met Office, the UK's national weather service. "We are really entering an unprecedented situation."

According to preliminary numbers from the World Meteorological Organization's (WMO), global average temperatures in 2023 were about 1.4°C above the pre-industrial average measured between 1850 and 1900. That smashed the previous record from 2016 by more than 0.1°C. "That's a big jump, equivalent to five years of global warming," says Scaife.

Factors that made 2023 so hot are likely to push the dial even further next year, possibly raising the annual average above the totemic 1.5°C target for the first time. (Omar Baddour at the WMO says one dataset suggests temperatures in 2023 may have exceeded 1.5°C, but the actual number is likely to be lower.)

The most significant of these factors is global warming driven by the rising concentration of greenhouse gases we are releasing into the atmosphere, which was responsible for about 1.28°C of the rise seen in 2023.

The other major factor is the shift to warmer El Niño conditions in the Pacific after the colder La Niña pattern persisted for three years in a rare "triple dip". Historically, the warming influence of El Niño is greater the year after it first develops, as the anomaly strengthens into December and January. "Usually, El Niño is a synonym of extreme events around the world," says Baddour.

"THIS COMBINATION OF FACTORS HAS NEVER OCCURRED IN RECORDED HISTORY, SO WEATHER PREDICTIONS ARE MURKY"

ALAIN PITTON/NURPHOTO/SHUTTERSTOCK

Other, smaller factors behind 2023's heat, such as unusually hot temperatures in the North Atlantic Ocean and a volcanic eruption in 2022 that injected water vapour into the upper atmosphere, may also add to next year's temperatures. "2024 is going to be extreme," says Scaife.

Jennifer Francis at the Woodwell Climate Research Center in Massachusetts anticipates "continuing weirdness, surprises and records broken by large margins" in 2024. While we could see the classic impacts of a strong El Niño – for instance, drought and heat in South America, Australia and South-East Asia – unusual combinations of ocean temperatures could affect the jet stream that drives weather in unexpected ways.

"This combination of factors has never occurred in recorded history, so predictions about [the next few months'] weather are particularly murky," she says.

Still, Francis says she would be very surprised if the global average temperature for all of 2024 rose more than 1.5°C above the pre-industrial average. Scaife says it is hard to say without clear forecasts, but thinks it is possible we see average temperatures next year rise above 1.5°C.

Crossing this threshold for a single year wouldn't be a breach of the Paris agreement target to keep temperatures below 1.5°C – that would require the 20-year average to rise 1.5°C above the pre-industrial average.

But Scaife points out this has little bearing on the impacts of that heat on people and ecosystems right now. "Whether it slightly tips over or not makes no difference," he says. "The point is we're very close." ▮

COP28 promised an end to fossil fuels, and now 2024 must start to deliver

James Dinneen

THE end of 2023 saw a global agreement at the COP28 climate summit to transition away from fossil fuels. In 2024, will we actually see reductions in emissions from burning oil, gas and coal? Maybe.

Certainly, political will is high. "We are moving away from fossil fuels," said US climate envoy John Kerry just after the agreement was adopted in Dubai, United Arab Emirates. "We're not turning back. That is the future."

A key sign of whether this translates into action in 2024 will be where the fossil fuel industry invests its trillions of dollars in revenue, says David Waskow at the World Resources Institute, an environmental non-profit organisation. In 2022, only around 2.5 per cent of total spending by fossil fuel companies went to clean energy, and 2023 saw several make massive bets to expand oil and gas development. Waskow says this ratio between clean energy and fossil fuel investment needs to be flipped in the next few years.

There are no strong indications yet that fossil fuel firms are planning for this shift, though. Following the Dubai agreement, even COP28 president Sultan Al Jaber, who played a key role in wrangling the global deal, signalled his enthusiasm to continue. Al Jaber, who is also the chief executive of the UAE's national oil firm, ADNOC, told *The Guardian* that his company would carry on investing in fossil fuels. "The world continues to need low-carbon oil and gas and low-cost oil and gas," he said, claiming ADNOC's fuels are "low carbon" due to more efficient extraction methods.

Even if fossil fuel firms don't act, we may see stronger moves from governments. Under the 2015 Paris Agreement, countries are meant to set more ambitious climate targets every five years. The next ones are due in early 2025, but some may be submitted in 2024. If the Dubai agreement has changed political thinking, we should see it here. "What are they going to include on shifting away from fossil fuels?" says Waskow. "What are they going to include on renewables, transport, nature, land, forests?"

These pledges are determined by national politics and circumstances, so vary widely between countries. Watch for a change of tune on coal from India as solar booms on the subcontinent, an embrace of renewable energy in many African nations and a shift in the trajectory of emissions from China as its economy slows and moves away from heavy industry. The US presidential election in November will prove consequential too. Whether or not Donald Trump is on the ballot, climate change will be.

The 2024 climate calendar will end with the COP29 summit in Baku, Azerbaijan, setting up a second round of debate on the future of fossil fuels in a major oil-producing country. The other centrepiece issue in Baku is expected to be marshalling the finance to actually deliver on commitments agreed to in Dubai. These include the hundreds of billions of dollars vulnerable countries need to adapt to climate change, and the more than $4 trillion a year in clean energy investment required to make the transition away from fossil fuels more than just words on paper.

> "A REAL SIGN OF PROGRESS IN 2024 WILL BE WHETHER GLOBAL GREENHOUSE GAS EMISSIONS BEGIN TO DECLINE"

However, ultimately, only one metric matters. A real sign of progress in 2024 will be whether global greenhouse gas emissions begin to decline, says Piers Forster at the University of Leeds in the UK, something that must happen by 2025 to keep both the Paris Agreement's 1.5°C and 2°C targets on track. Some forecasters think this could happen next year, but Forster cautions that actual measurements of atmospheric concentrations of greenhouse gases will be needed to demonstrate a peak. "The proof is in the pudding," he says. ▮

5

Climate activists at the COP28 climate summit earlier this month

REUTERS/RULA ROUHANA

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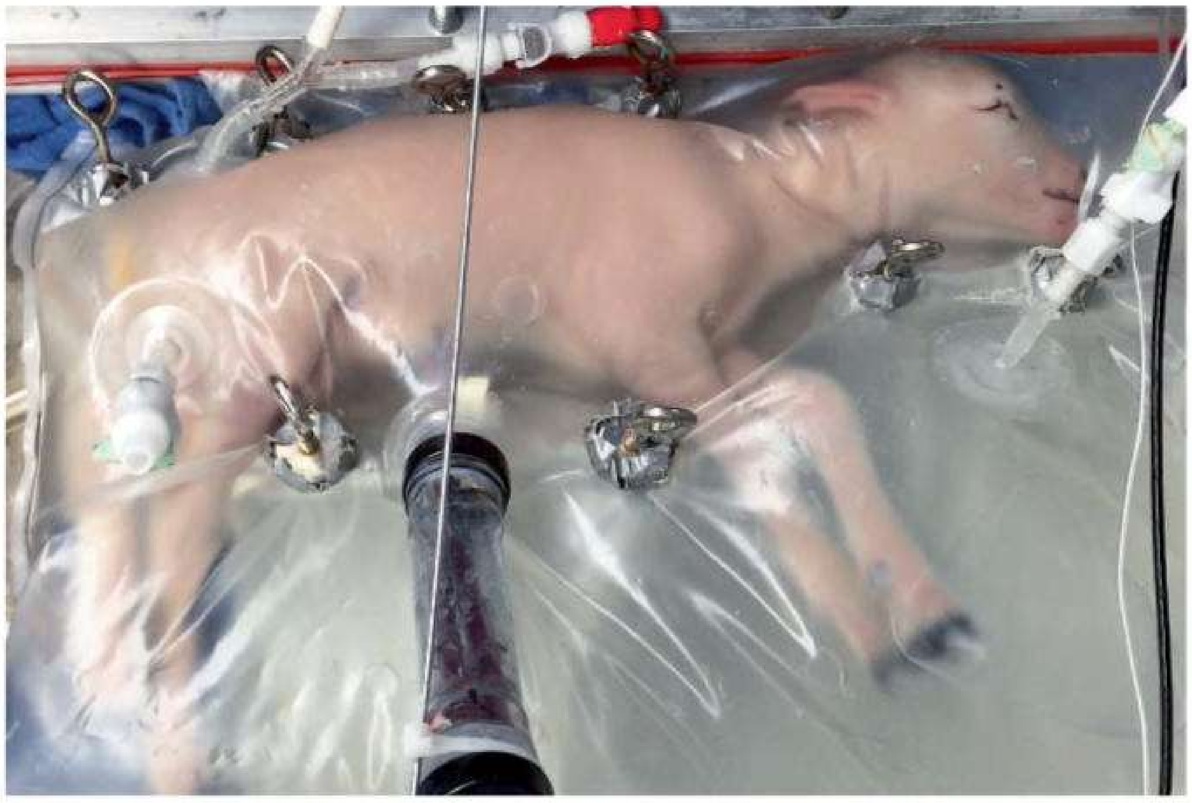
Neonatal health

Artificial uteruses on the horizon

After successful trials in hundreds of premature lambs, a US agency has hinted that it may soon approve a first-in-human study of an artificial uterus, reports **Alice Klein**



PARTRIDGE, E., DAVEY, M., HORNICK, M. ET AL. (2023)

6

The EXTEND system has kept more than 300 preterm lambs alive

THE groundwork is being laid for the first human trial of an artificial uterus, which could get the go-ahead from the US Food and Drug Administration (FDA) some time in 2024.

Artificial uteruses are designed to mimic the environment of the womb as closely as possible and may help support babies who are born extremely prematurely, at around 23 or 24 weeks' gestation.

"The idea is to bridge the rough patch when they're really struggling and carry them through to a point when they can do OK," said Emily Partridge at Children's Hospital of Philadelphia, Pennsylvania, in a video about EXTEND, her team's artificial uterus system, which has shown promise in animal studies.

Extremely preterm babies have difficulty breathing, even with the help of mechanical ventilators. This is because their immature lungs struggle to transition from being filled with fluid, as they were in the uterus, to breathing air. Being unable to breathe properly is one of the main reasons why only around 50 to 70 per cent of these infants survive, and why those who do often develop brain damage or other medical conditions.

The EXTEND system consists of a "bio-bag" filled with warm, lab-made amniotic fluid to mimic the uterus's environment. The idea is that a preterm baby could be placed inside the bag straight after delivery to retain fluid in their lungs. Surgeons would also connect blood vessels in their umbilical cord to tubes for delivering oxygen, nutrition and medicines.

Experiments involving more than 300 preterm lambs showed that the artificial uterus kept them alive and facilitated healthy development of their lungs, brains and other organs.

Off the back of these, the FDA has signalled that it may soon approve a first-in-human trial of the system. In September, it convened a meeting of more than two dozen neonatologists, paediatricians, bioethicists and other experts to discuss what such a trial might look like.

"THE IDEA IS TO CARRY NEWBORNS THROUGH TO A POINT WHEN THEY CAN DO OK"

Alan Flake – one of EXTEND's developers, also at Children's Hospital of Philadelphia – told the meeting that he believes the team's preclinical data "is adequate for consideration of a carefully designed clinical study".

The panellists weighed up potential risks and benefits, and discussed ethical dilemmas regarding how to recruit the first trial subjects. For example, Mark Mercurio, a neonatologist and bioethicist at Yale University, noted that preterm labour is "often a setting of fear, of exhaustion, of urgency and pain", meaning parents may not be in the right frame of mind to provide proper consent.

However, Mercurio also said that he believed the artificial uterus's potential benefits could outweigh any of its risks if it were first offered to help extremely preterm babies with less than a 20 per cent chance of survival. "I think this is a very promising technology, and while I think we have to approach it with caution and eyes wide open, and with an open and thorough discussion of the ethical issues, I think we should move forward with those discussions," he told the meeting.

The technology's development has led some to wonder whether the next step will be using artificial uteruses to grow babies all the way from in vitro fertilisation embryos, bypassing the need for pregnancy altogether.

However, writing in *The Journal of the American Medical Association* in June, Flake and his colleagues dismissed this as "nothing more than a technically and developmentally naïve, yet sensationally speculative, pipe dream". Early organ development relies on chemical signals that an artificial uterus cannot supply and the blood vessels of fetuses younger than around 23 weeks' gestation would also be too tiny to connect to it, they argue.

The FDA barred the public from the section of the meeting in which it and the EXTEND developers discussed the potential timing of a clinical trial. We will therefore have to watch this space to see if one does get the green light in 2024. ▮

Artificial intelligence

Creators fight back against AI

Tech giants are gearing up for a series of potentially bitter legal battles over claims they used copyrighted material in training data, says **Alex Wilkins**

ARE cutting-edge developments in artificial intelligence built on a foundation of mass copyright infringement? We may start to find out in 2024. In the US, there are nine separate class-action lawsuits against AI firms, including OpenAI, Meta and Google parent company Alphabet. One of those, Getty Images vs Stability AI, is also being tried in the High Court in London.

Though each case varies on the specifics, accusations of copyright infringement are a common theme. AI firms infringed copyright, say the claimants, by taking intellectual property from the internet, like whole books or artworks, to train their models.

The people who own those works want to be compensated, while the AI firms very much don't want to pay out. "Imposing the cost of actual or potential copyright liability on the creators of AI models will either kill or significantly hamper their development," wrote tech investment firm Andreessen Horowitz, which has significant holdings in AI companies, in a submission to the US Copyright Office in November.

Now, the courts are getting involved. The US class-action lawsuits, in which the plaintiffs represent a broader group, like any artist whose works were used to train a model, could have wide-ranging implications, so lawyers must first set out their arguments carefully to show they merit class-action litigation. A back-and-forth will then ensue between the plaintiffs – who will try out different arguments, some stronger than others – and the defendants, who will try to dismiss the arguments, either through previous cases or existing law.

"SOME FIRMS FACE ALLEGATIONS THEY TOOK INTELLECTUAL PROPERTY FROM THE INTERNET TO TRAIN THEIR AI MODELS"

7

OMAR MARQUES/SOPA IMAGES/LIGHTROCKET VIA GETTY IMAGES

Stability AI will face off against Getty Images in a copyright infringement case in 2024

"People say a lot of crazy things in a class-action pleading," says Matthew Sag at Emory University in Atlanta. "There's no particular incentive to be judicious, to only run your best arguments, to only say things that you can actually back up with facts."

Arguments that can't be dismissed through this process will then be tried in court, but there is very little chance we will see such cases settled next year, says Sag. "Class-action lawsuits are never fast. The only way they're fast is if they just completely flame out." A similar legal claim – against Google for copyright infringement over its book digitisation project, Google Books – took almost a decade to resolve, being decided in favour of the tech firm in 2015.

We might find out more from Getty Images vs Stability AI, which is being tried in the UK. Stock photo company Getty Images alleges that Stability AI, which is based in London, infringed copyright by training its AI image generator, Stability Diffusion, using Getty's material.

There is little public information on Stability AI's arguments for the defence. The firm did attempt to dismiss the lawsuit, claiming that the training of its model wasn't done in the UK, but the High Court rejected this in December. Both parties have been regularly attending hearings to decide the shape that the case will take, says Matt Hervey, head of artificial intelligence law at legal firm Gowling WLG in London, and the case should conclude in the second half of 2024. Gowling WLG isn't involved in the proceedings.

If the claim proceeds to trial in London, Stability AI might find it tougher to mount a defence there than in the US. "There are very few exceptions that are suitable for training AI on expressive works in the jurisdiction of the UK," says Hervey.

If Getty were to win, this could encourage other claimants to try to seek compensation from AI firms, but it might be hard to find a defendant. "Most of these [AI] companies have really come out of the west coast in the US," says Hervey. "I'm not aware of any other juicy targets in this country who have openly trained on copyright materials."

Developments in any of these cases might lead to some AI companies "jurisdiction shopping" – training their models in countries where the chance of legal action is lower. A ruling against Stability AI, as well as the current regulatory and legal landscape in the UK, could persuade firms to opt to do their AI training in places like the US, where the legal system appears more favourable, says Hervey. ▮

GAERTNER/ALAMY

8

Crawford Lake in Canada has been proposed to mark the start of the Anthropocene

Geology

Has human activity put Earth into a new epoch?

Chen Ly

WE MIGHT be thrust into an entirely new epoch in 2024, as scientific bodies make an official decision about whether the impact of humans on the planet over the past few decades is enough to mark a new geochronologic unit.

First popularised by meteorologist Paul Crutzen in 2000, the term Anthropocene broadly refers to a time of significant planetary change as a result of human activities, such as deforestation and burning fossil fuels. Some experts believe that Earth has transformed so much that the Anthropocene may have already supplanted our current epoch, the Holocene, which began 11,700 years ago.

In July 2023, the team of scientists tasked with defining the potential new epoch, called the Anthropocene Working Group (AWG), selected Crawford Lake in Canada as the site with the best geological evidence for this. Plutonium isotopes from nuclear weapons fallout at the bottom of the lake date the start of the Anthropocene to the early 1950s.

The news came as a surprise to many, as sites chosen to mark new timescales are usually only publicised after they have been ratified by the International Union of Geological Sciences (IUGS).

"Establishing it in the media before scientists are able to vote on [the proposal] might make it more difficult to reject," says Erle Ellis, a former AWG member at the University of Maryland.

But Simon Turner at University College London, who is a current member of the AWG, says science should be an open process. "We consider this of significant public and wider interest."

Some researchers disagree with the move to define the Anthropocene as a geological epoch. Ellis, who resigned from the AWG shortly after the selection of Crawford Lake was announced, believes the group's definition of the Anthropocene diminishes the impact of humans before the middle of the 20th century. "It's not what the science tells us about the human age," he says.

Philip Gibbard at the University of Cambridge also opposes the proposal. "If you have a boundary in 1950, that makes me Holocene because I was born in 1949," he says. Instead, Gibbard, Ellis and others suggest that the Anthropocene should be defined as an ongoing event.

In response to such concerns, AWG member Colin Waters at the University of Leicester, UK, says humans have been affecting the planet throughout the Holocene, but "big changes consistently happen around about 1950".

At the end of October 2023, the AWG submitted a formal proposal to its parent body, the Subcommission on Quaternary Stratigraphy (SQS), Turner told *New Scientist*. If the SQS accepts the proposal, it must pass two further rounds of voting by the International Commission on Stratigraphy and the IUGS before it is officially added to the geological timescale.

By August 2024, we may officially be living in the Anthropocene. "Recognition of the rapidity of this global change within the last 70-odd years would be really significant," says Turner. "We're confronted by the fact that had we not burned all this fuel from the mid-20th century, we would be in a very different place."

If the proposal is rejected, however, it could appear as if we are overlooking the outsized influence of humans over the past few decades, says Waters. "It's almost akin to someone saying climate change doesn't exist." ▮

11,700
Years since our current epoch, the Holocene, began

1950
Approximate date proposed as the start of the Anthropocene

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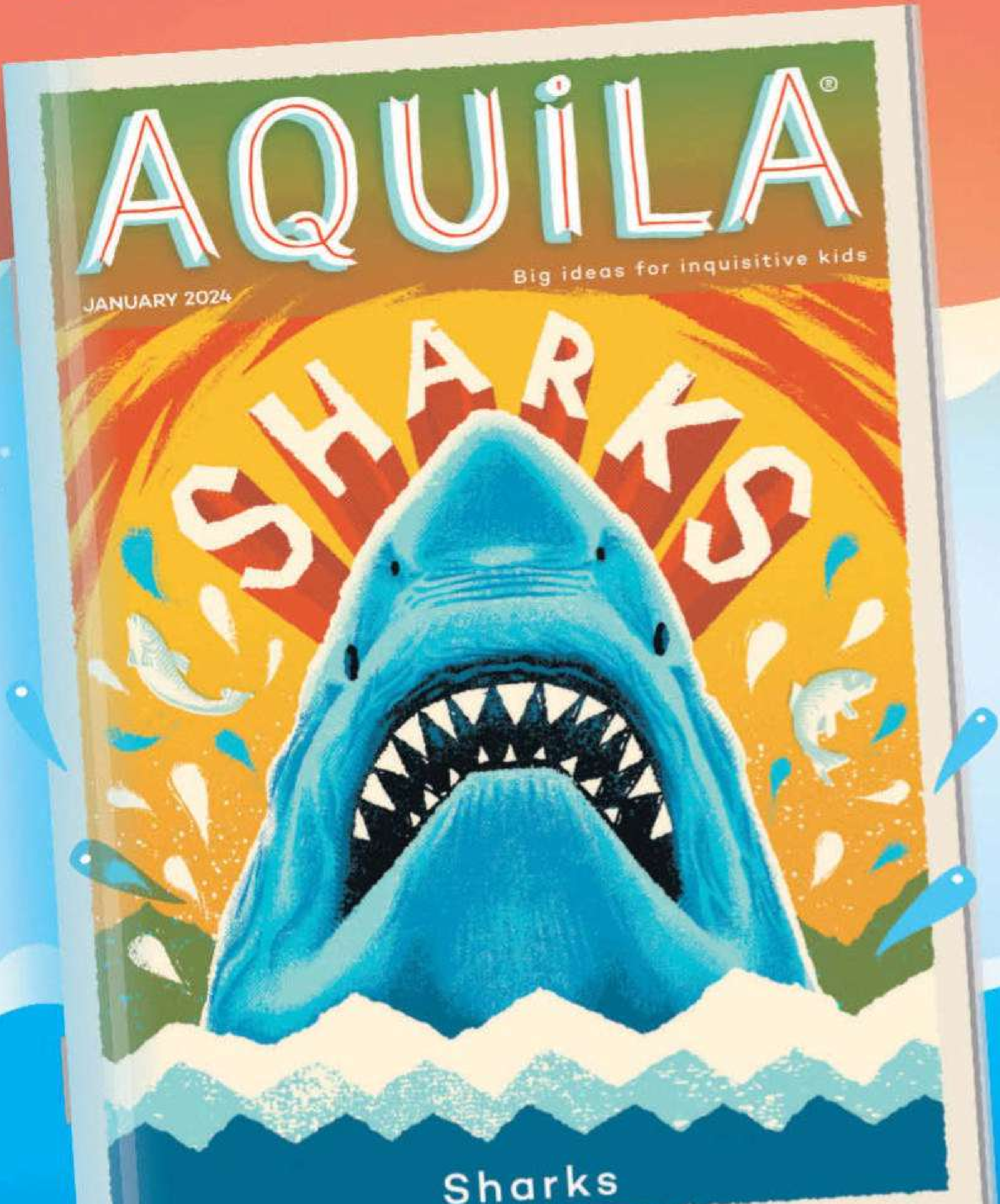

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Space exploration

The lunar armarda

An extraordinary number of missions are headed to the moon in 2024, with landers, orbiters and perhaps even crewed vehicles set to make the trip, says **Leah Crane**

IN 2024, the world's space agencies are shooting for the moon. More than 10 missions are headed to Earth's satellite, most of them intending to land on its surface and all paving the way for human lunar exploration.

"It is the year of the moon," says Bethany Ehlmann at the California Institute of Technology. "The number of moon missions in 2024 is really a reflection and a realisation of the momentum from the last five years or so – it's a big global push."

The barrage is set to begin in January, with the planned landing of Japan's Smart Lander for Investigating Moon (SLIM) craft, the country's first lunar lander. Around the same time, a lander developed by the US company Intuitive Machines will launch. This lunar craft, along with most of the others launching in 2024, is part of NASA's Commercial Lunar Payload Services (CLPS) initiative, in which the agency funds commercial craft going to the moon to foster future exploration and build industry partnerships.

> "THE NUMBER OF MOON MISSIONS IN 2024 IS REALLY A REFLECTION OF THE MOMENTUM FROM THE PAST FIVE YEARS"

Over the course of the year, the CLPS missions will investigate and attempt to mine ice on the moon, test technology designed for future missions, work on how to deal with the sticky lunar dust and demonstrate a wide variety of new types of rover.

One such mission, called Cooperative Autonomous Distributed Robotic Exploration (CADRE), will include three rovers and a base station, all operating autonomously to take measurements at different locations across the lunar surface, working from a general mission plan.

"The autonomy aboard the robots takes that high-level objective and computes what each needs to do individually to achieve that objective without any further instruction," says Jean-Pierre de la Croix at NASA's Jet Propulsion Laboratory in California. If it works, this set-up could drastically boost the productivity of robots on future missions.

It isn't just landers headed to the moon – new orbiters will also support them. The Lunar Trailblazer orbiter, which is part of the CLPS programme, will be particularly important to future human explorers, who will need to extract water from lunar ice. "This will provide the first maps of water at the surface that are truly actionable – you land on the surface and you know if you drive left or you drive right," says Ehlmann. "Our data will basically provide signposts that say 'go here next'."

Not all of 2024's moon missions will be sent up by NASA, of course. Along with Japan's SLIM, orbiters are being sent from Canada, Germany and Singapore, and even the Finnish electronics company Nokia is sending a rover. In May, China plans to launch the Chang'e 6 mission to return the world's first samples from the far side of the moon.

Rounding off the year, NASA's Artemis II mission is planned for November, along with two important flights of SpaceX's Starship craft near the end of 2024 – one an uncrewed moon landing and the other the dearMoon flight, which will send several artists on a flyby.

All of these missions – especially Artemis II, which will see four astronauts flying near the moon and back over the course of 10 days – are ramping up to increasingly sophisticated human lunar exploration in the coming decades. "Seeing the moon up close will really bring that perspective that, no kidding, it is a real and separate body in open space," says Christina Koch, one of those four astronauts. "Getting to be a part of that mission, doing something we haven't done in over 50 years, is just absolutely phenomenal."

NASA

An artist's impression of Intuitive Machines's Nova-C lunar lander

9

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Comment

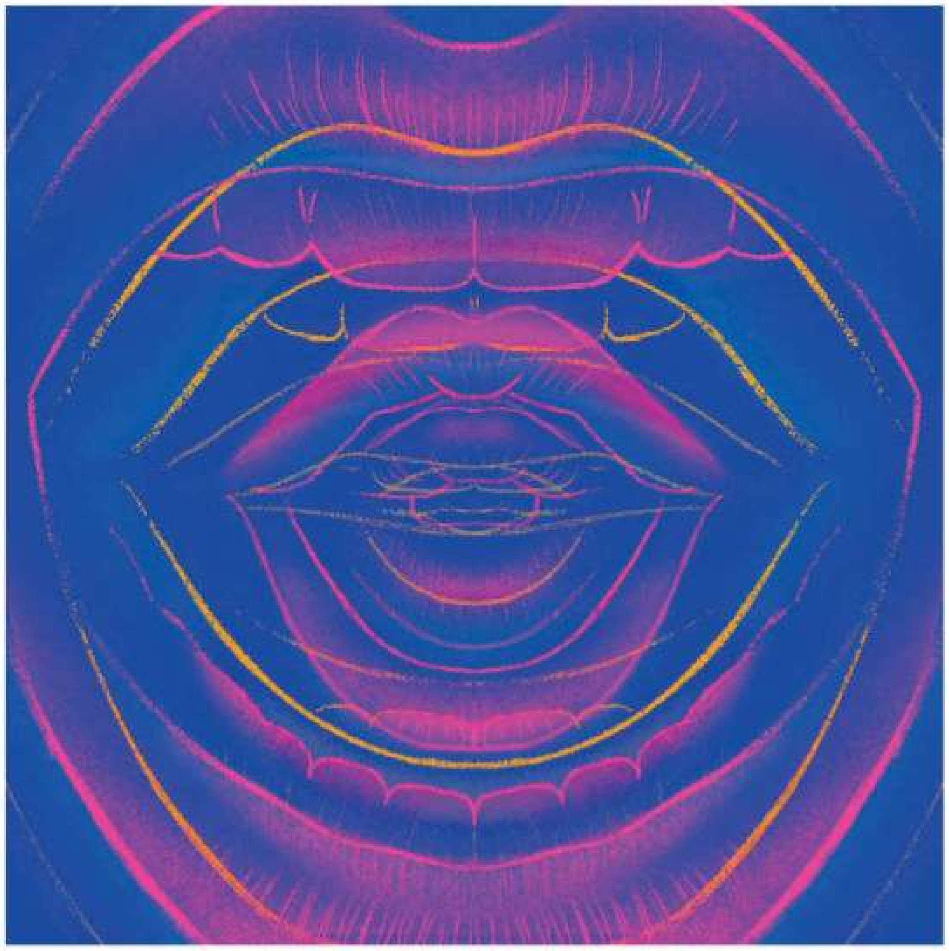
Tower of Babel

Artifical intelligence will make it easier than ever to communicate across linguistic borders. But is this good, asks **Philip Seargeant**

FROM the very beginnings of recorded history, there has been a desire to create a single language that could unite humankind. Allegorised in the biblical story of the Tower of Babel, as well as in origin myths from cultures around the world, the belief has always been that the diversity of languages – there are over 7000 spoken today – is a problem for which we need to find a solution. This has led, down through the centuries, to many a scheme trying to craft some form of truly universal communication.

To date, however, none of these have properly succeeded. But with the recent rapid improvements in artificial intelligence, it looks as if this ambition might finally be within reach.

The solution turns out not to involve the manufacturing of a single universal language – an Esperanto or Basic English – but instead the development of frictionless, computer-mediated translation that is embedded within the technologies that have become an integral part of everyday life. Rather than the need for everyone to speak the same language, this approach means that I can speak in my preferred language and you will hear my message, in real time, in yours. The fact we are speaking different languages will simply be irrelevant as far as understanding each other is concerned.


ELAINE KNOX

Early versions of this are already in use. For example, auto-translate for foreign-language postings on Facebook has been around for a few years now, and there are a number of earbud translators on the market that act as real-life, if somewhat primitive, Babelfish.

The technologies that make this possible – multilingual machine translation, natural language processing and so on – have come along in leaps and bounds over the past few years. The AI tools developed by Meta, for instance, can now translate directly from and into any combination of a hundred different languages. They can also work with languages that are primarily spoken rather than written and thus don't have an archive of texts on which to train the AI model.

Given the momentum in this area, it seems perfectly likely that some form of viable universal communication will be part of everyday life by the end of the decade. But there is a very important question we should be asking about all this: what impact will it have on society and culture as we know it?

The Babel myth, which casts a long shadow over how we think about the topic, is based around the idea that linguistic diversity and multilingualism are flaws in the human faculty for language – that they are a problem, and thus in need of a solution. In reality, they are fundamental features of the system, which give language its flexibility, and upon which whole cultures and identities are built.

It is this inbuilt urge for diversity that is the main reason why all the schemes for universal languages never quite fulfilled their inventors' ambitions. As communities shift and grow, so do their linguistic habits. And while language is, of course, a means for communicating with others, it is also a means for differentiating yourself from others. So technologies that find ways to bypass or render invisible this diversity will have significant ramifications for human society.

This isn't to say that a technology that harnesses simultaneous translation to make it possible to communicate effortlessly across linguistic borders won't be an immensely convenient tool. But as with all innovations to the way we communicate, it is likely its impact will be both deep and far-ranging in ways we can't fully predict. So in the quest to overcome the age-old "confusion of languages", we need to also look to protect the huge variety that characterises our global linguistic culture. ▮

Philip Seargeant is a linguist at the Open University, UK, and author of *The Future of Language*

This changes everything

California dreaming A strange city could take shape north of Silicon Valley, funded by venture capitalists. Its founder rejects the "utopian" label, but **Annalee Newitz** isn't convinced

Annalee Newitz is a science journalist and author. Their latest novel is *The Terraformers* and they are the co-host of the Hugo-winning podcast *Our Opinions Are Correct*. You can follow them @annaleen and their website is **techsploitation.com**

Annalee's week

What I'm reading
The recently launched neuroscience magazine The Transmitter.

What I'm watching
New Doctor Who*!*

What I'm working on
Making pad kee mao, aka the Thai dish drunken noodles.

This column appears monthly. Up next week: Alex Wilkins

FOR the past six years, a mysterious group called Flannery Associates bought up swathes of farmland north of San Francisco in Solano county. Now that it has amassed over 200 square kilometres, it has gone public with plans to build a city and revealed the name of the project, California Forever.

Jan Sramek, CEO of the operation, said he has been working with investors including venture capitalist Marc Andreessen and LinkedIn co-founder Reid Hoffman. They aim to build an instant community that will house nearly half a million people. This news dispelled years of rumours that the land grab was part of a secret military project, due to its proximity to an air force base. But none of this has made Solano county residents happy because they worry Sramek – a former finance industry superstar and self-help influencer – will create a haven for the rich that drains resources from the region without giving anything back.

Sramek and a few colleagues have been holding town hall meetings around Solano county to talk to residents and pitch their still-vague plans. Reports from these events are full of comments from attendees who express frustration that Sramek won't divulge details of exactly where and how the city will be built. Instead of reassuring concerned citizens, he referred cryptically in a recent meeting to knowing things about regulations his detractors don't.

At one session, in the city of Vallejo, he spoke to *KQED* reporter Adhiti Bandlamudi. "Before we ever started investing, we did a lot of research on the county," he said. "And so, actually, we do know more about the county than almost any other developer that would come in here." When residents asked how the proposed city would get water and manage traffic on the already congested highway nearby, he said California Forever was working on figuring it out. It was more of a deflection than a full answer, and mirrored talking points from the firm's online FAQs, which make a lot of vague promises to work with the county.

Sramek framed negative responses as sour grapes from people who couldn't solve problems on their own. "Every time someone says, 'I don't like your project', we say, 'OK, what's your proposal for fixing these issues?' Because it's really easy to be a critic. It's really hard to build something in the world today," he argued. The thing is, nobody in Solano county was asking for solutions like California Forever.

> **"Residents worry that this new city will be a haven for the rich that drains resources from the region"**

Certainly the county needs help with problems like water access, infrastructure maintenance and police corruption. But nobody expressed a desire for a sprawling luxury city for thousands of residents who don't live there yet. Ill-feeling includes a dispute with some property owners. Indeed, locals are so resistant to the development plans that California Forever's Flannery Associates has filed lawsuits over land acquisition, suing several people who didn't sell, accusing them of conspiring to drive up land prices.

Perhaps one of the most curious claims made by Sramek is that his city will not be "utopian". And yet the closest analogue to California Forever might be the city imagined by Ayn Rand in her novel *Atlas Shrugged*, in which industrialists led by John Galt flee to an urban utopia in rural Colorado to escape the horror of labour strikes. Sramek's plans also have elements of the garden city imagined by British urban planner Ebenezer Howard, which, in turn, inspired architect Frank Lloyd Wright's iconic suburbs in the US. Unfortunately, those suburbs were dependent on cars and wound up contributing to the kinds of unsustainable, resource-depleting developments that California Forever claims to reject.

Perhaps what Sramek means is that California Forever isn't a utopia because it will be real, and not just a dream. After all, the word utopia is a reference to the Greek for "no place". However, as long as California Forever remains a vaguely-defined, unbuilt project, it is, in fact, no place. California Forever is, by the strictest definition, utopian.

For the many Solano county residents whose lives are about to be turned upside down by this new development, though, it might be more like dystopia. To them, it is as if strangers from Silicon Valley have plonked themselves down in a land where they don't belong and are trying to copy-paste a city onto farmland, as if they were playing *Minecraft*.

This approach has faint echoes in the history of California settlement itself, where strangers from Europe violently pushed out the local Indigenous peoples for hundreds of years, often in the name of building a better world.

In this state, where we build futuristic dreams and tech that supplies the world with wonder, it is all too easy to forget the past. But it haunts us anyway. ▮

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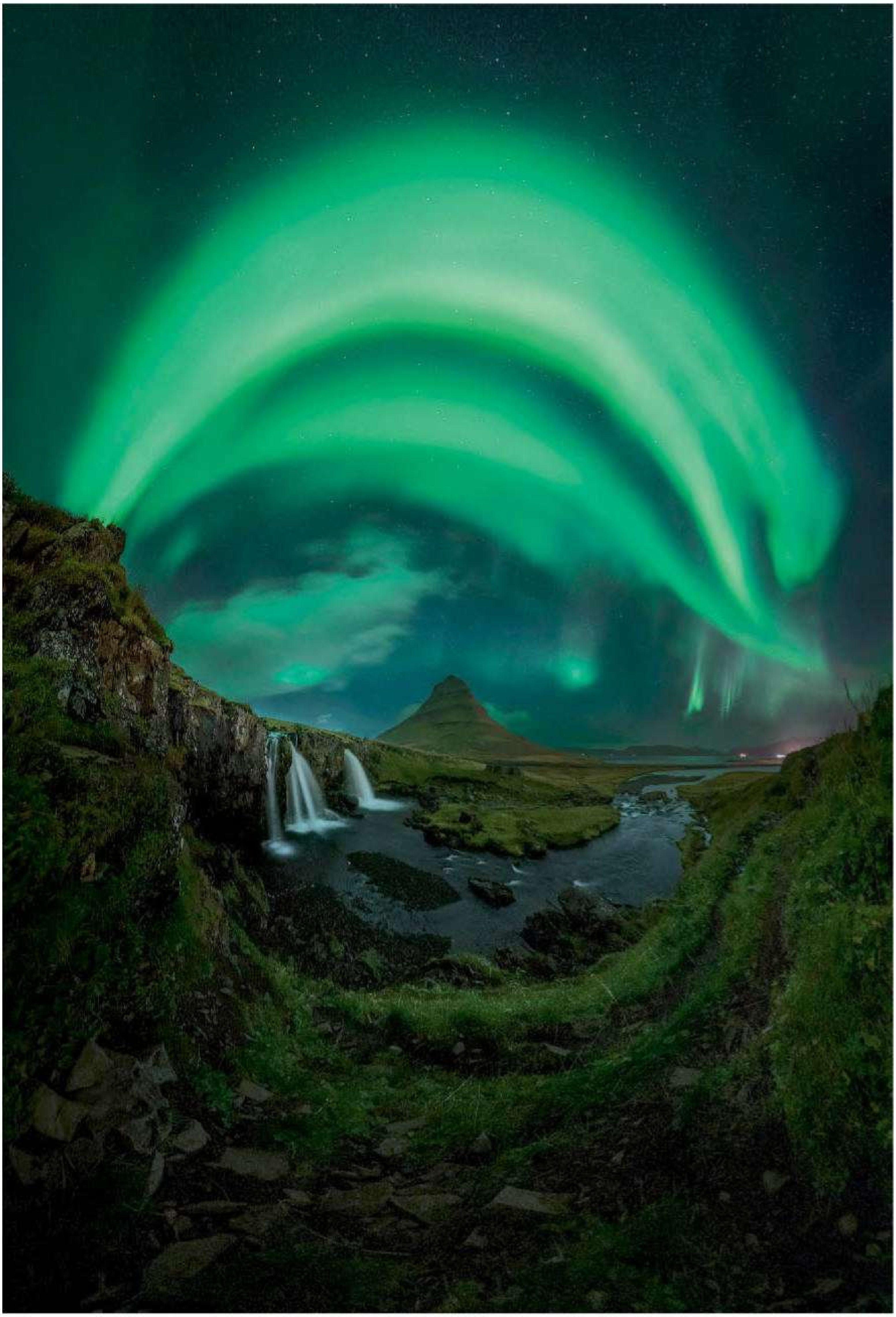

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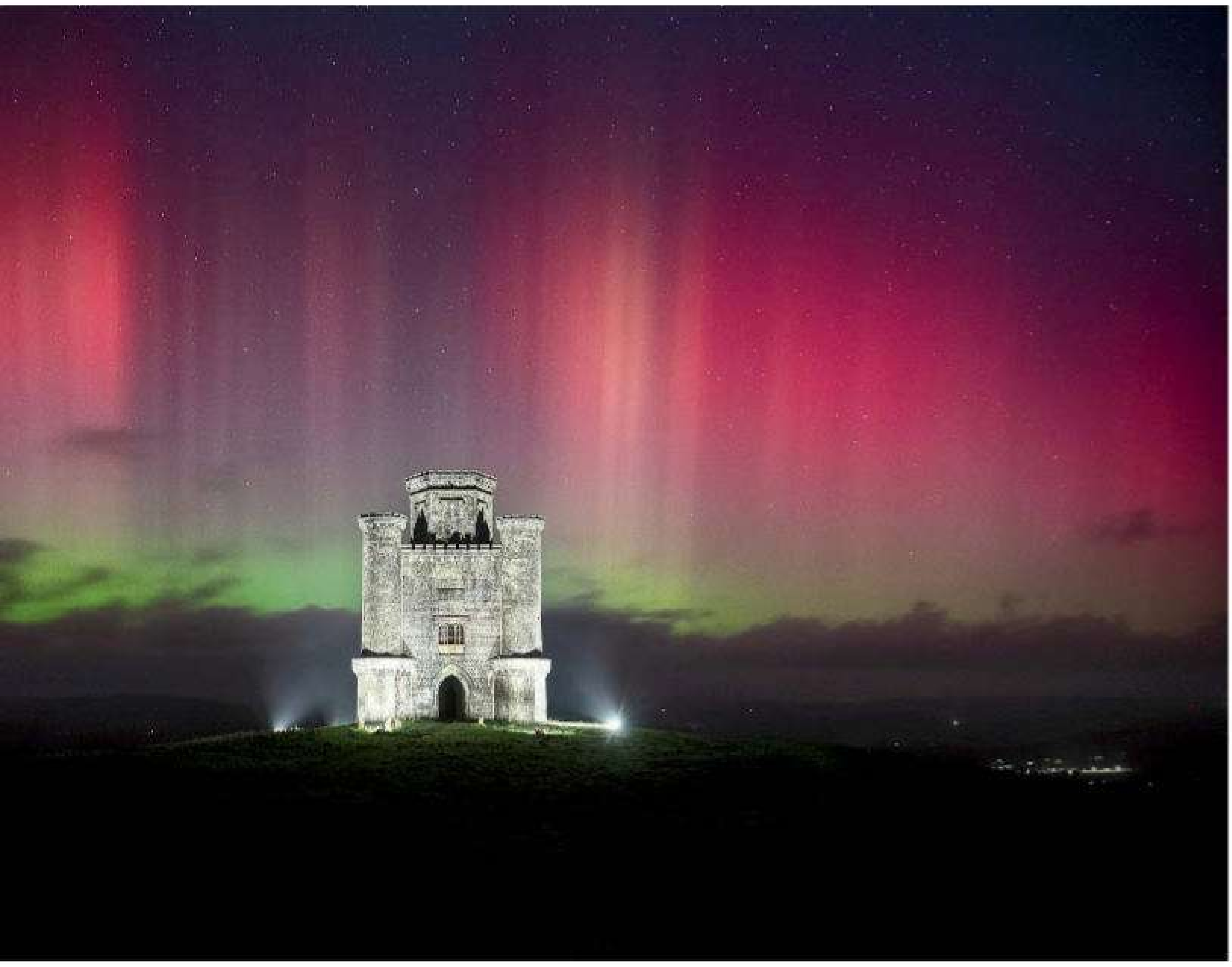
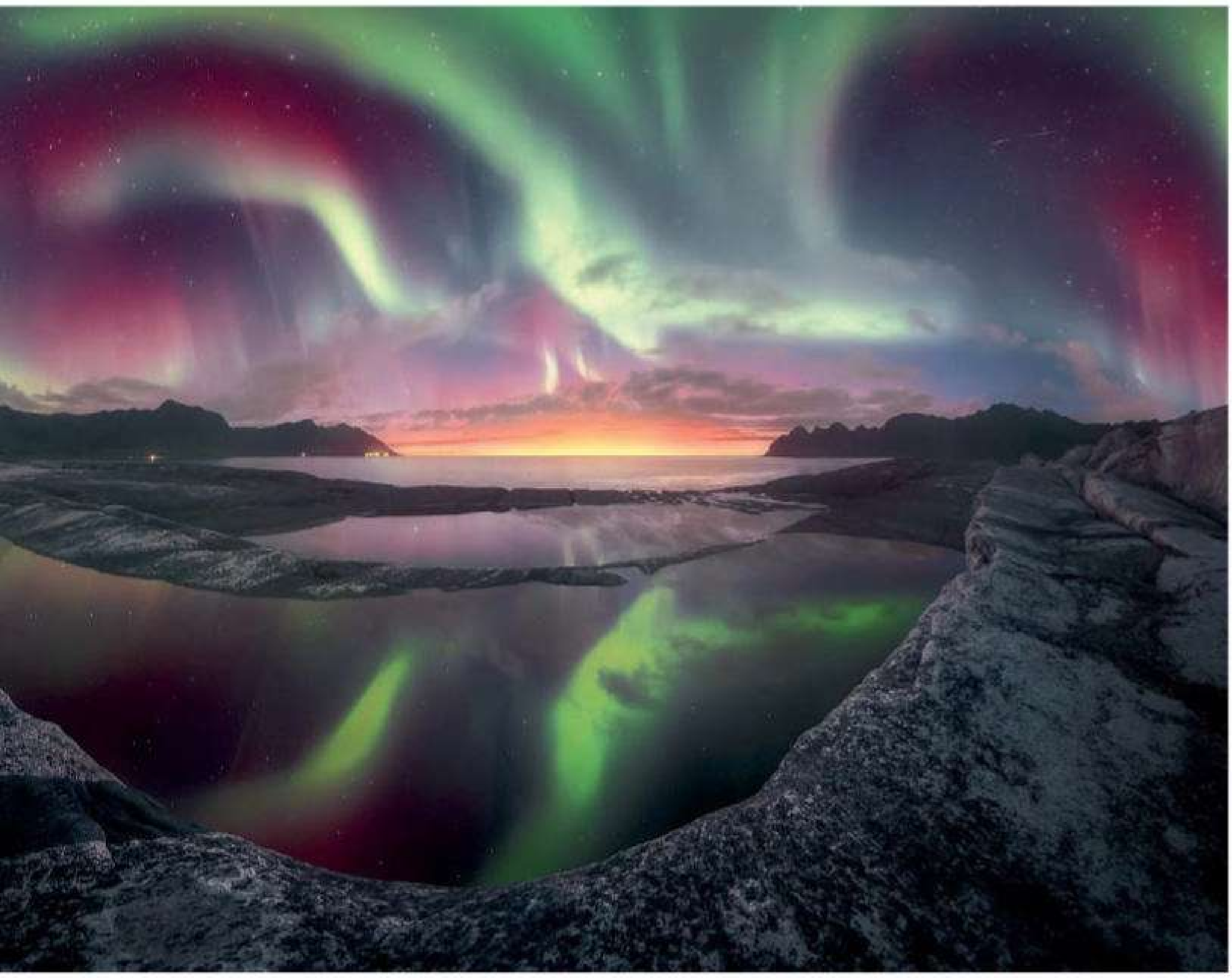




Light up the sky

Capture the Atlas

THERE are few sights as spectacular as aurorae, and they are used to dazzling effect in the Northern Lights Photographer of the Year contest, run by travel photography blog Capture the Atlas.

This year, 25 breathtaking shots from around the world have made the final cut, a selection of which are shown here and on the next two pages. Each brings a special dimension to this extraordinary phenomenon, which is caused by charged particles from the sun colliding with atmospheric gases.

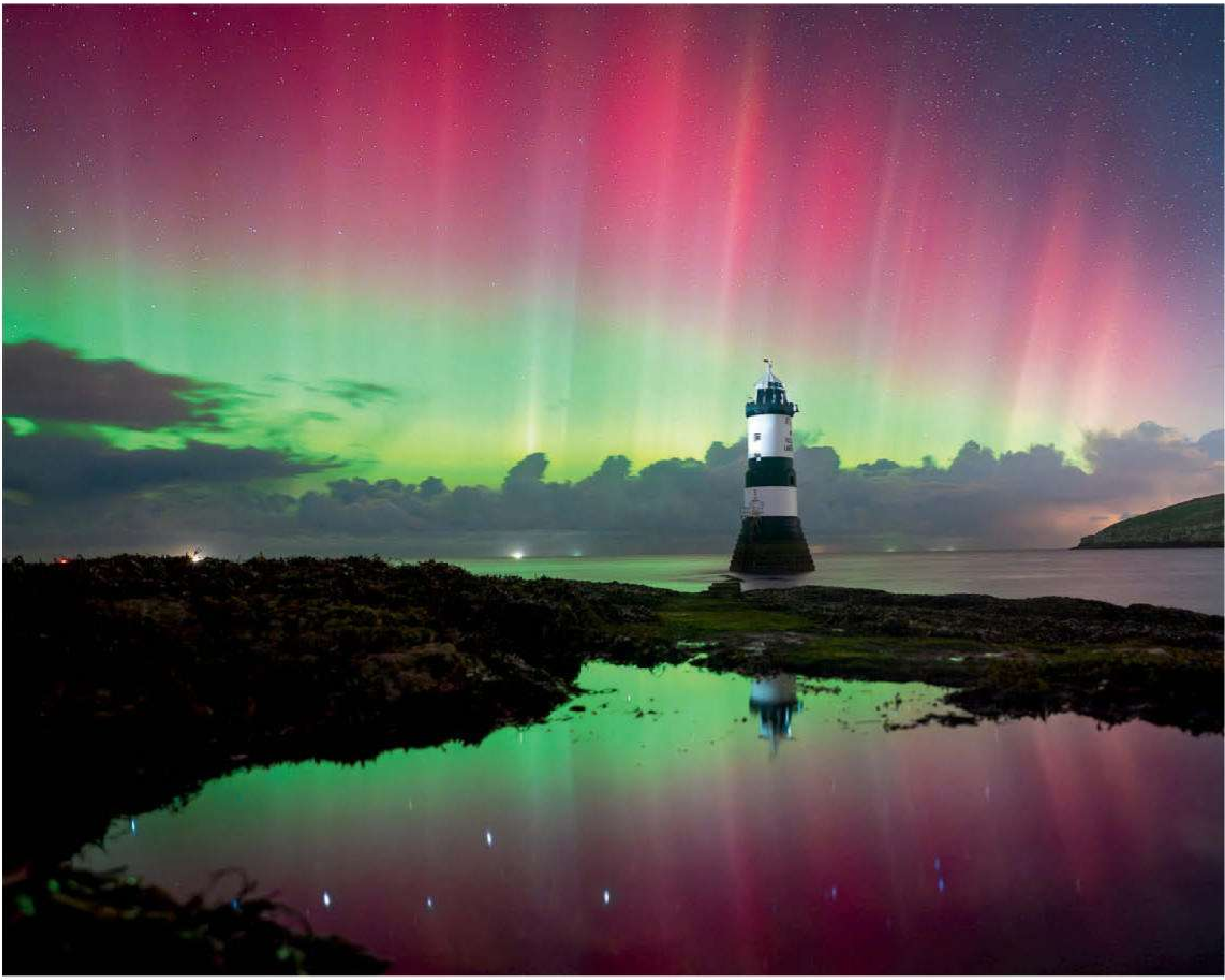
With the next peak of the sun's activity (known as its solar maximum) approaching in 2024, people are already catching a glimpse of aurorae – both northern and southern – in wider regions than usual. Next year's displays are set to be even more spectacular.

Many of the shots in 2023's competition were taken in locations where it is unusual to see the northern lights, such as south Wales, captured in Mathew Browne's *Goleuadau'r Gogledd* (top right). The name is a loose Welsh translation of "northern lights", and the image shows local landmark Paxton's Tower illuminated. "Witnessing the aurora borealis this far south is a rare occurrence," said Browne. "For over an hour, the horizon beyond the clouds emitted hues of green and pink. However, for a brief yet magical moment, the sky came alive with impressive pink pillars, visible to the naked eye."

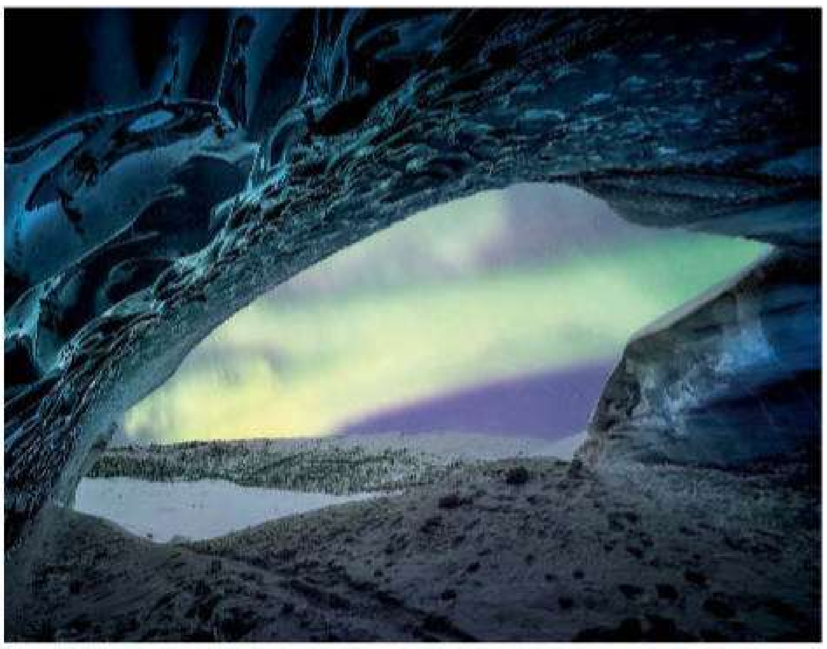
Also shown are Marc Marco Ripoll's *Kirkjufell Explosion* (far left), taken near Iceland's Mount Kirkjufell; and Alex Wides's *Waning Sun*, shot on Senja Island, Norway (bottom right). ▮

Gege Li

Images continue on the next page

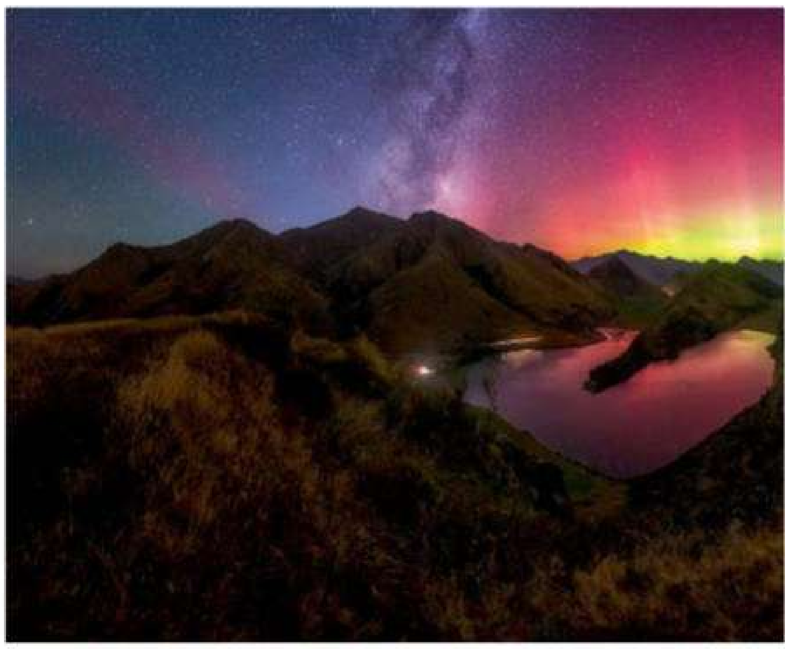


KAT LAWMAN



MARYBETH KICZENSKI

Clockwise from top left: *Island of Aurora* taken by Kat Lawman in northern Sweden; Frøydis Dalheim's *Circle of Life*, taken in Finland at almost -30°C; the aurora australis, captured in *Lost Who I Want To Be* by Jordan McInally at Moke Lake, New Zealand; *Fleeting Moments on Ice*, shot from an ice cave in Alaska by MaryBeth Kiczenski



JORDAN MCINALLY

FROYDIS DALHEIM

Science to look out for

Why is gravity still a puzzle? Do humans make pandemics? Are we all ocean people? 2024's best reads probe our toughest questions, finds **Simon Ings**

TRUTHS and consequences dominate the books we are likely to read in the year ahead. We escaped the food chain, but now we have to defend the living world we once fought against. We have left the planet only to discover all the unexpected ties that bind us to it. Some of us now lead easy lives – for which we reap surprising and unhappy consequences. What can the science that drove our success do to ensure our survival?

HADYNYAH/GETTY IMAGES

Irresistible attraction

We are still a very long way off from understanding how the world works. We still have no clear idea why what goes up must come down. The puzzle of gravity has driven Claudia de Rham's adventures in science. In *The Beauty of Falling* (Princeton University Press), we follow her from being an astronaut hopeful to becoming a research physicist.

Frank Close brings a particle physicist's perspective to bear on the same puzzle in *Charge* (Oxford University Press). The secret to gravity, the force that shaped the cosmos, may lie in the exquisite balance of electrical charge within the atom.

Hunter killers

Luckily, Close and de Rham are able to research their world without damaging it. Early natural historians never had that moral luxury, says Jason Roberts, whose *Every Living Thing* (Quercus) tells the story of the rivalry between the great 18th-century cataloguers of life on Earth, Carl Linnaeus and Georges-Louis de Buffon. The legacy of their battle – without committing such heinous crimes as introducing invasive species – lives on as we struggle to save the living world.

The contributors to behavioural ecologist Martha Crump's diverting collection *Lost Frogs and Hot Snakes* (Comstock Publishing Associates) are Linnaeus and de Buffon's successors, dangling off cliffs and dealing with leeches to understand the amphibians and reptiles critical to Earth's vitality.

Field studies of this sort are where art and science meet. Lavinia Greenlaw's *The Vast Extent* (Faber) is a poet's response to the puzzle of how we see and understand the unseen. How do we describe what we have never seen before? What helps us see more clearly or persuades us to see what isn't there?

In *We Loved It All* (W. W. Norton), meanwhile, novelist Lydia Millet asks how our perspectives must change if we are to refrain from destroying the very lives we love to observe. It is a personal evocation of the glory of nature to warm the heart of every field scientist.

The social network

Our understanding of animal societies expands at an ever-accelerating rate. In *The Well-Connected Animal* (University of Chicago Press), evolutionary biologist Lee Alan Dugatkin demonstrates that whatever creature you are – from a giraffe to a Tasmanian devil – life is all about who you know.

And the more we understand animal societies, the more we realise how "animalistic" we are. We aren't, after all, the only animal that cries, laughs, loves or has a moral sense, as Jessica Serra's *The Beast Within* (Johns Hopkins University Press) reveals.

The big oddity about humans is that we adapt with incredible speed to changes we ourselves have tinkered into being. This doesn't happen smoothly, though, and in *The Anxious Generation* (Allen Lane), social psychologist Jonathan Haidt investigates the collapse in youth mental health that has followed the rise of smartphone, "selfie" culture and, broadly, the decline of real-world social networks.

Daniel Freeman, a clinical psychologist, offers a more anecdotal, but arguably even more shocking exploration of similar territory in *Paranoia* (William Collins), examining what makes us mistrustful and asking how we can overcome this way of thinking.

And in *The Last Human Job* (Princeton University Press), sociologist Allison Pugh sets out on another important quest: urging us to recognise, value and protect humane work in an increasingly automated and disconnected world.

Caught out

Unusual animals run unusual risks and, according to Sabrina Sholts in *The Human Disease* (The MIT Press), human beings are, by their nature, uniquely vulnerable to pandemics because what we do and what we are helps create them.

Whether humans are uniquely able to overcome them is a moot point. Dali Yang's account of China's handling of the covid-19 outbreak in *Wuhan* (Oxford University Press) is fascinating, though also daunting and terrifying as we read how it spiralled out of control.

The more we study that global crisis for lessons, the bigger and more difficult those lessons become. In *The Rich Flee and the Poor Take the Bus* (Johns Hopkins University Press), economist Troy Tassier shows the many entangled and often unexpected ways that people with low incomes bear the brunt of epidemic disease.

Getting to grips with these systemic problems enables us to protect against the next pandemic and also to view other phenomena through an epidemiological lens. In *How War Kills* (Johns Hopkins University Press), researcher Yara Asi looks at armed conflict as a huge threat to public health beyond the battlefield and offers new ways of mitigating its effects.

Numbers game

New perspectives on the human plight are always welcome. In *The Price of Life* (Picador), journalist Jenny Kleeman traces the unintended consequences of cost-benefit analysis and asks what we lose and gain by using cold logic for the judgements that really matter.

Sociologists Marion Fourcade and Kieran Healy believe shifts in moral opinion have occurred now that our lives are being so closely measured, ranked and processed. (When was the last time you rode with an unrated taxi driver?) Their book, *The Ordinal Society* (Harvard University Press), is a powerful indictment of these automated measures of merit and the way they produce insidious kinds of social inequality.

French economist Daniel Cohen, who died this year, capstoned his career with a similar polemic: *Homo numericus*, enumerating the many ways the digital revolution has created a new economy and sensibility that is moving us out of civic life and our own mental well-being.

The next wave

The dark side of economic logic dominates Olive Heffernan's account of *The High Seas* (Profile Books). Owned by all nations and no nation simultaneously, our oceans, home to extraordinary biodiversity, are also witness to extraordinary acts of extraction and exploitation.

In *What the Wild Sea Can Be* (Atlantic Monthly Press), marine biologist Helen Scales asks what can be done to protect them and, thank goodness, finds hope. She has a distinct view on the human condition: no matter where we live, "we are all ocean people". ▮

Simon Ings is a writer based in London

New sci-fi horizons

Extraordinary science fiction novels await the intrepid reader in 2024, says **Sally Adee**

EVEN in the future, history never stays in the past tense. The most anticipated books of 2024 explore the deep roots of the moral and philosophical quandaries shaping our times.

Many depths are visible in *Exordia* (Tor), Seth Dickinson's clever take on a first-contact-with-aliens, military sci-fi, moral philosophy tome. If all that hasn't got you running away screaming, this book is for you.

Alien contact with the military industrial complex also dominates *Jumpnauts* (Simon & Schuster) by Hao Jingfang, translated by Ken Liu. Here, the aliens may prevent a world war in a barely recognisable future.

Robin Sloan's *Moonbound* (MCD) is similarly far out, in all senses, with its timelines: one a near future where our problems have been solved; the other 11,000 years ahead, with our species mostly a cautionary tale.

Parallel universes feature prominently in Joma West's *Twice Lived* (Tordotcom), as some children flip uncontrollably between parallel realities, sometimes disappearing for long stretches. In the end, they can only settle in one. West observes the emotional devastation this creates. It is an elegant metaphor for what we all face as our choices collapse into our settled identity.

What happens to those identities if we are stripped of our memories? The eponymous protagonists in P. Djèlí Clark's *The Dead Cat Tail Assassins* (Tordotcom) are raised from the dead to take on contracts, unable to recall their former lives – until one does.

> "One of our oldest questions is whether to stay holed up inside the wall or to go over"

Unreliable memory warps cultures too, as we find in *The Truth of the Aleke* (Tordotcom), in which Moses Ose Utomi expands *The Lies of the Ajungo*, his acclaimed novella. History as a one-sided tale told by its winners echoes through both.

What happens when history's winners are replaced by their own creations? *Service Model* (Pan Macmillan) by Adrian Tchaikovsky follows a robot in search of a new paradigm. You can count on Tchaikovsky to make the most of the complex ethics involved; even at 400 pages, it is over too soon.

YAGI STUDIO/GETTY IMAGES

In Oliver K. Langmead's colony-ship space opera *Calypso* (Titan), an engineer wakes from cryostasis to find a centuries-long war still raging between technologists and botanists over the kind of utopia their society will build on their new home.

And when (or if) a utopia is achieved, how do you keep it going? This is the heart of Tlotlo Tsamaase's Afrofuturist folk/horror/sci-fi novel *Womb City* (Erewhon), in which technology traps a woman in her own body.

Technology has other perils, judging by Ray Nayler's *The Tusks of Extinction* (Tordotcom), a *Jurassic Park* updated for the 21st century. What does de-extinction really do, if it can't restore the past?

We have all longed for a mulligan – that second chance. Peng Shepherd scratches that itch in *All This and More* (William Morrow), as a game show uses quantum tech to undo contestants' deepest regrets.

Even top writers have those. In 1980, Haruki Murakami published a story, *The City and Its Uncertain Walls*. Forty years on, restrictions of the covid-19 pandemic gave him the chance to return to it. The result is a novel of the same name (an English translation is possible in 2024). As Murakami said at the book launch in Japan in 2023: "In an age when society is going through rattling changes, whether to stay holed up inside the wall or to go to the other side of the wall has become a greater proposition than ever." It is one of our oldest questions. ▮

Sally Adee is a writer based in London

The TV column

Second take After an epic Hollywood writers' strike destroyed schedules, shows like *Fallout* and *3 Body Problem* should finally air in 2024, alongside some beguiling documentaries and gritty British dramas. Fingers crossed, says **Bethan Ackerley**

Bethan Ackerley is a subeditor at *New Scientist*. She loves sci-fi, sitcoms and anything spooky. She is still upset about the ending of *Game of Thrones*. Follow her on Twitter @inkerley

APPLE TV+

Adam Scott (Mark) and Britt Lower (Helly) in *Severance*

GOD laughs at those who make plans. The same could be said of those who write television previews. Last December, I blithely enthused about the 2023 arrival of *3 Body Problem*, *Fallout* and the second series of *Severance*, none of which ultimately materialised. This year's Hollywood strikes, needlessly drawn out by those seeking to deny writers and actors a fair shake, delayed TV production for months and put paid to those already quixotic predictions.

Chastened but undeterred, I am trying again for 2024 – and I am delighted to say that at least two of those series will air in the coming year. *3 Body Problem*, the first English-language adaptation of Cixin Liu's towering sci-fi novel, is set to arrive on Netflix in March. This era-spanning alternate history, which begins during China's Cultural Revolution in the 1960s, sees humanity make contact with an alien civilisation in an unstable triple-star system.

And in April, Amazon Prime Video's long-awaited *Fallout* series finally arrives. I was happy to learn that, while the show is inspired by the popular video game franchise of the same name – where a retro-futuristic society is nuked into near oblivion and survivors traverse a ghoul-infested wasteland – it tells a new story.

As for the return of *Severance*, a sci-fi thriller on Apple TV+ about a company separating its workers' memories of their personal and professional lives, we have no ETA. But I am hopeful that the second season will arrive in 2024 and live up to the show so far, which was one of the two best of 2022.

> **"The final season of *Star Wars* series *Andor* is due in August. Prepare for heartbreak and high stakes"**

The other? For me, it was *Andor*, a *Star Wars* series about a thief being gradually radicalised into fighting the Empire. The first season was a stunningly realised look at ordinary people's lives in fascist states, so ambitious and unlike anything in this franchise that it blew expectations out of the water. The second (final) season airs on Disney+ in August: prepare for heartbreak and high stakes.

That's a lot of sci-fi, so let's take a detour. Netflix is adding to its natural history catalogue with *Our Oceans* and *Our Living World*. Even more exciting is a 10-part nature documentary from BBC Studios Natural History Unit, set to arrive in the first half of 2024. Narrated by Tom Hanks and with a score by Hans Zimmer, *The Americas* will explore the fragile ecosystems of Earth's largest landmass.

As a devotee of gritty British dramas, I must mention a few. *Truelove*, due on Channel 4 on 3 January 2024, sees two childhood sweethearts, in their 70s, reunite at a wake at which the mourners agree to help each other die with dignity when the time is right.

Jack Thorne, the mind behind this year's staggering medical drama *Best Interests*, has written a series for Netflix about one of the UK's biggest toxic waste scandals. *Toxic Town* follows three women fighting for justice in the town of Corby. Rounding out this trio, ITV's *Playing Nice* has a fascinating premise: two couples learn that their sons were swapped at birth and must consider whether to reclaim their biological children.

Fancy something lighter? From the great Sally Wainwright comes *Hot Flush*, a BBC series about five women who form a punk band to finally express their thoughts on life, love and the menopause. And Netflix's *The Decameron*, based on a 14th-century collection of short stories, is a soapy dramedy about fleeing the Black Death of 1348. Neither has an official air date, so perhaps I still haven't learned last year's lesson. ▮

Bethan also recommends...

TV

I Think You Should Leave with Tim Robinson

Tim Robinson, Zach Kanin

Netflix

Every so often, I become desperate to recommend a show that has no link to science whatsoever – when better to do so than in the dog days of the year? This surreal sketch show is the funniest thing on television.

Deadloch

Kate McCartney and Kate McLennan

Amazon Prime Video

Another non-science hit from 2023, this is a black comedy about the discovery of a body in a sleepy Tasmanian town. Deadloch's citizens are a riot – and the case is pleasingly knotty.

Editor's pick

Hard to swallow a 1.5°C+ world as anything but bad

2 December, p 21

From Walter Edgar, Glasgow, UK

I was astonished by your comment article "Keeping our cool". It is subtitled: "Despite pessimism, limiting global warming to well below 2°C is within our grasp."

The writer states: "And while 'well below 2°C' is very much in reach, we are clear the tougher 1.5°C goal no longer appears feasible… And a 'well-below 2°C' world won't be pretty, as social tipping points, including mass movement of people and conflict for resources as vast areas around the equator become effectively uninhabitable, strain global cohesion and economic and political stability."

So avoiding 2°C of warming is supposed to be good news? Exceeding 1.5°C is the sort of catastrophic situation that climate scientists and others have warned of.

Extending lifespan may not be such a good thing

2 December, p 9

From Christopher Young, Sheffield, UK

In media coverage on the topic of significantly extending human lifespans, there seems to be a general view that doing so would be an unalloyed good. But the most significant impact would be an increase in population. If we all lived an average of 12 per cent longer than at present, that would amount to another billion people, disproportionately older. I don't see how this would be a good thing.

Best use for sunlight navigation device

2 December, p 12

From Sam Edge, Ringwood, Hampshire, UK

I read with interest about the "insect-eye" compass that can navigate by the sun even on cloudy days. While I can see a use for it in drones, it is relatively easy to compensate for the magnetic fields drones generate, and hence conventional systems can work. Where it may come in handy is for manual or autonomous navigation at high latitudes where Earth's magnetic field at the surface becomes closer to vertical and begins to give less and less information about horizontal direction.

Indeed, there is some (albeit disputed) evidence that early northern European navigators, such as the Vikings, used natural crystal polarisers to determine the direction of the sun when visibility was too poor for it to be seen.

This is why we must be wary of geoengineering

25 November, p 11

From Arthur Dahl, Geneva, Switzerland

The study that found there is a weekend boost to plant productivity in Europe because of reduced air pollution by aerosols, which block sunlight, should be a warning to those who seek to address global heating by injecting aerosols into the atmosphere.

This research shows how sensitive plants are to any drop in sunlight. Addressing climate change through atmospheric geoengineering will reduce plant photosynthesis on land and at sea globally, with probably catastrophic impacts on nature and agriculture.

A passing star may yet wreak havoc on Earth

9 December, p 12

From Peter Slessenger, Reading, Berkshire, UK

It is suggested that the orbits of planets in our system would probably be unaltered by a star passing at about 100 astronomical units from the sun. But what of the many Oort cloud and Kuiper belt objects? They would be much closer to the passing star and more easily disturbed. Could the planets expect a bombardment of comets and asteroids?

When rooks lined up to admire their reflections

Letters, 2 December

From John Magrath, Oxford, UK

Following on the discussion about animals that might recognise their own reflection: when a riding school near me installed mirrors in its outdoor arena, I saw how the local rooks lined up on the fence and spent a long time looking at their reflections. After observing them numerous times, I concluded they were using the mirrors for preening and admiring the results (and each others' looks). Maybe that isn't true self-awareness, but it seemed similar to human vanity.

Go carefully when it comes to AI's wonder materials

2 December, p 8

From Roger Morgan, Presteigne, Powys, UK

The arrival of the GNoME artificial intelligence model to predict new inorganic crystal structures is indeed exciting. Its positive potential is justly lauded, having increased the number of known inorganic crystal structures from around 48,000 to over 2 million, with potential for making better batteries, solar panels, computer chips, alloys and more.

But there is a worrying quote in the story: "You know the structure might exist, but if you don't know what it does, then it's not clear whether to make it or not." The history of new wonder materials is made up of huge benefits and some toxic disasters. This AI-driven leap in potential materials bears promise, but may also be the harbinger of disasters. We should devote as much research to assessing possible risks as to the possible benefits of new materials.

We need to know the true price of a cuppa

2 December, p 40

From Penny Wilde, Hull, East Yorkshire, UK

You highlight the need to clarify the true cost of products on various grounds. It struck me that one good example of where this is needed is for the tea we drink, because production can take place in impoverished places. If factories aren't run to Western standards and a living wage isn't paid, that keeps prices artificially low.

We use the labour of these workers, take their wealth and criminalise them when they come to Western nations wanting a share of it. We make our own immigrants by both waging war and paying unrealistic prices.

On the road to a car-free utopia

Letters, 2 December

From Merlin Reader, London, UK

Recent correspondence ponders car culture and how to address it. Cheaper goods in more local shops, stopping motorised "school runs" and a culture of promoting (free!) public transport etc. would be far better than pushing even electric private vehicles.

On the hunt for the oldest examples of art

18 November, p 32

From Brian Reffin Smith, Berlin, Germany

Did any of the teams looking at "art" dating back millions of years include an artist? If art academics studied a million-year-old activity that resembled science without a scientist, we would laugh. ▮

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Open wide!

Hordes of oral bacteria can migrate around your body, with serious consequences for your long-term health. Luckily, there are ways to keep them on side, says **Jasmin Fox-Skelly**

IT IS always the same vibe: the glossy, out-of-date magazines, the smell of sterilising fluid, the inevitable fish tank. Dentists' waiting rooms aren't much fun, and when you go through to the surgery, it only gets worse. The chair tilts back with an electric whir, the masked face says "open wide" and out comes an array of sharp, metal implements. No wonder many of us emerge rubbing our gums and wondering how long we can put off our next appointment.

But perhaps we need to recalibrate our relationship with our oral health, because there is a consensus emerging that looking after it might be the underappreciated secret to a longer, healthier life.

What matters isn't so much having pearly whites per se, but looking after our oral microbiome: the viruses, fungi and 700 or so species of bacterium that reside in our mouths. Let our oral hygiene slip, and bad bacteria from there can travel all over the body, causing or exacerbating problems, from cardiovascular disease and cancer to Alzheimer's disease and arthritis. Keeping everything in balance, on the other hand, staves off decline.

Here's the good news: now we are coming to understand the importance of the oral microbiome, there are things we can do to keep it in tip-top condition. That doesn't just mean brushing and flossing, but could include new vaccines against gum disease and even bathing your gums in an oral microbiome replacement composed of microbes from our long-lost hominin ancestors. Going to the dentist won't be any more pleasant, but we have all the more reason to grin and bear it.

Over the past decade or so, biologists have shown that we are festooned with microbes, inside and out. This microbiome, composed of bacteria, fungi and viruses, profoundly influences who you are. It is the gut microbiome that gets the most limelight. We know it influences our health and fitness and is even linked to our emotional state.

The oral microbiome gets far less attention, but we have known of it for a long time. In 1891, US dentist Willoughby D. Miller first proposed that bacteria could leave the mouth, travel to other parts of the body and cause disease. Frank Billings, co-founder of the Institute of Medicine of Chicago, later speculated that tooth infections may be the cause of rheumatoid arthritis, among other diseases.

We only began to get supporting evidence in 1989, when Kimmo Mattila, a doctor at Helsinki University Central Hospital in Finland, and colleagues noticed that people who had experienced a heart attack were rated as having oral health that was about twice as poor as that of a control group, even when age, social class and smoking habits were accounted for. A solid link seemed to be there.

More recently, DNA sequencing technology has improved apace, enabling us to catalogue the microbes in our mouths. Thanks to this, we are now finding that the types of bacteria people have living there seem to be associated with a growing number of conditions. We know, for instance, that people with gum disease are as much as 20 per cent more likely to get cancer in their lifetimes compared with otherwise healthy people.

But perhaps the most striking example is Alzheimer's disease. We have known for a while that people with gum disease are at increased risk of developing this condition, which slowly robs people of their memories, personalities and cognitive function. However, until recently, it was unclear whether poor oral health was a contributing cause of Alzheimer's or a consequence of it.

Then, in 2019, scientists discovered species of bacteria known to cause gum disease – including one called *Porphyromonas gingivalis* – living inside the brains of people who died of Alzheimer's disease. There were also gingipains, protein-degrading enzymes produced by *P. gingivalis*, in their hippocampi, a region of the brain responsible for memory. Meanwhile, mice with chronic gum disease were found to have inflammation, neural damage and build-ups of beta-amyloid protein plaques in their brains – one of the hallmarks of Alzheimer's disease. If the mouth bacteria were getting into the brain, that lent weight to the idea that they could be a cause of Alzheimer's.

Hide out and multiply

We are also starting to grasp how this could happen. The biology of the mouth makes it a vulnerable point. Where the teeth meet the gums is a tiny gap called a sulcus. In a person with healthy teeth and gums, this gap is small, but if you don't brush properly, bacteria can build up, causing inflammation. As the gums become more inflamed, they start to pull away from the teeth, and a deeper pocket forms. Harmful bacteria can hide and multiply in this airless environment, and then, if you have bleeding gums, they can get into your bloodstream. "The teeth are the weakest link of the body," says periodontologist Alpdogan Kantarci at the Forsyth Institute in Cambridge, Massachusetts.

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RONALD KURNIAWAN

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> **“Could we swap our bad, modern oral microbes for our ancestors’ healthy ones?”**

But thanks to our immune systems, the survival time of foreign microbes in a person’s bloodstream is usually minimal. So, how can bacteria reach the brain? Intriguingly, in a study earlier this year, Kantarci and his collaborators showed that oral bacteria could be hitching a lift inside the body’s own immune cells. His team took neutrophils, a type of white blood cell, from people with no significant health issues. These cells are experts at gobbling up invading bacteria. However, when Kantarci and his colleagues introduced them to *Fusobacterium nucleatum*, a bacterium commonly found in the mouth, the microbes survived being swallowed by the neutrophils. Rather than killing them, the white blood cells acted like Trojan horses, protecting the bacteria from other immune cells and transporting them over large distances. After travelling for a while, the neutrophils broke apart, releasing their dangerous cargo.

Kantarci is also getting insights into how Alzheimer’s may take hold once oral bacteria are in the brain. In a second study, he and his colleagues gave mice gum disease, observed how the bacteria migrated to the rodents’ brains and then measured how the numbers of various cells in the brain changed. Their key finding involved a type of immune cell called microglia, many more of which were activated when the bacteria appeared in the brain.

Microglia act as first responders, destroying invading pathogens and sending out chemical signals that summon other immune cells to join the fight. They are also responsible for destroying beta-amyloid plaques. So, in the brains of such people, microglia are already working double time. Kantarci thinks that, when the oral bacteria arrive, they tip the already overextended microglia over the edge and kick off a snowball effect of inflammation. Scientists already suspect that inflammation might be the underlying cause of Alzheimer’s disease. In that view, the oral bacteria might be another contributing factor, perhaps the straw that breaks the camel’s back.

Bacteria from the mouth can migrate and wreak havoc in a range of other places too, including the gut. “Normally, if a healthy person swallows bacteria, they are either killed on the way down due to the acidity in the stomach or, once they get to the gut, there won’t be space for them because it’s already full of other bacteria,” says immunologist Joana Neves at King’s College London. However, she and others are starting to think that, if a person’s gut has a pre-existing problem, that creates an opportunity for mouth microbes to move in.

Take people with inflammatory bowel disease (IBD), a group of conditions in which the immune system attacks parts of the digestive system. One hypothesised explanation for IBD is that the gut lining is more oxygenated than usual, so the intestine is more accommodating to oral bacteria. There is evidence to support this: one study analysed the intestines of 39 people with IBD who were undergoing elective colon surgery and found that affected biopsy samples contained much higher levels of oral bacteria compared with nearby healthy colon tissue. In people with IBD, the gut lining could be leaky, enabling oral bacteria to get into the blood. This would then make the immune system go bananas and result in the gut attacking itself. There is already evidence from studies in mice that indicates this might be the case.

In the case of Alzheimer’s and IBD, then, we can think of oral bacteria as a critical factor that lowers the threshold at which an existing condition becomes problematic. For other conditions, though, some scientists believe oral bacteria can act as the cause.

Cardiologist Ntobeko Ntusi at the University of Cape Town in South Africa leads a team looking at the causes of atherosclerotic heart disease, in which fat and cholesterol build up

DR_MICROBE/ALAMY

***Porphyromonas gingivalis* is one kind of bacterium that causes gum disease**

in the arteries. This build-up, called plaque, blocks blood vessels and can cause a heart attack or stroke. Ntusi has found a strong link between disease severity and the type of bacteria a person has living in their mouth. And he isn't alone. Another study tracked more than 10,000 healthy volunteers over 15 years and showed that participants with gum disease were more than twice as likely to go on to have a stroke as people without the condition. Meanwhile, a separate analysis showed that gum disease and tooth loss increased the risk of coronary artery disease by 24 and 34 per cent, respectively.

This time, there is good evidence that oral bacteria are the direct culprit. In 2011, a team led by periodontologist Elena Figuero at the Complutense University of Madrid scraped plaque from the carotid arteries of people with heart disease and sequenced the bacterial DNA in it. The researchers found bacteria traditionally associated with gum disease in the plaque, including *P. gingivalis*. It seems that the oral bacteria are migrating to the arteries and settling down there. "They are very good at producing a protective layer of biofilm, which protects them from antibiotics and your own body's mechanisms of defence," says Ntusi.

Once they have set up home, oral bacteria cause atherosclerosis by provoking immune cells to release chemical messengers called cytokines. Cytokines turn LDL cholesterol, otherwise known as "bad cholesterol", into a special oxidised form that builds up on artery walls. Experiments in rodents and pigs have shown that even perfectly healthy animals can develop heart disease quickly if oral bacteria colonise their coronary arteries.

Clearly, letting our oral microbiome go bad is deeply risky. It would be easy to feel gloomy about all this. After all, who outside of Hollywood has perfect pearly whites? Happily, though, looking after our teeth isn't that difficult. Dentists recommend brushing your teeth with fluoride toothpaste twice a day and cleaning between them with floss or interdental brushes.

Even if you develop gum disease, there are effective treatments that can reverse this, such as deep cleaning under the gums, where dentists use special instruments to scrape plaque, tartar and bacteria from below the gum line. Antibiotics, gum surgery or having some teeth removed are also options. Kantarci says there is no evidence that cosmetic procedures like teeth whitening or veneers will either significantly help or harm your oral microbiome.

JAVIER TRUEBA/MSF/SCIENCE PHOTO LIBRARY

Neanderthal teeth, like these 64,000-year-old molars, were often in great condition

There may also be a way to protect yourself in advance. Dental scientist Eric Reynolds at the University of Melbourne, Australia, is developing a vaccine against gum disease. It works by getting the body to produce antibodies that detect and neutralise gingipains, those troublesome enzymes produced by *P. gingivalis*. In 2016, the vaccine was tested in mice that had been infected with the bacterium, and it protected the ridge in which teeth sit from degradation. Reynolds is now planning human trials.

Neanderthal gnashers

Meanwhile, anthropologist Laura Weyrich at Penn State University has a more radical idea. It grew out of work she and her team have been doing over the past decade; studying plaque on the teeth of human remains from as far back as about 20,000 years ago through to the modern day. In general, the oral health of Neanderthals and ancient humans was excellent, she says. There are only a few known examples of cavities in Neanderthal teeth, and these come from places where they ate acorns, a relatively sugar-rich food. But they did still get a gunky build-up of plaque on their teeth, and Weyrich's goal was to analyse the DNA in this to reconstruct a history of the human oral microbiome.

So far, she has found that the oral microbiome of our ancestors became markedly unhealthier after we switched from being hunter-gatherers to farmers about 8000 years ago. At that time, "people drastically shifted their diet and started eating more carbohydrates, and that selected for the types of microbes that we associate with things like dental cavities", says Weyrich. In unpublished work, she has since found that similar step changes in the oral microbiome occurred after the industrial revolution and the second world war.

Fascinating in themselves, these results also gave Weyrich an idea. Could we swap our bad, modern oral microbiome for the healthy version that ancient humans had? There would be a precedent for this, in the sense that faecal transplants are already used to help replenish the gut microbiome. For the oral equivalent, Weyrich envisages loading the bacteria into a device similar to a mouth guard that would be worn on the teeth for a short while, allowing the microbes to settle in the mouth.

Working with Peter Zilm at the University of Adelaide in Australia and his colleagues, Weyrich has identified a suite of beneficial microbes found in the mouths of our ancestors, as well as those of healthy volunteers. "We know that there are people alive today who eat lots of sugar, never brush their teeth, never go to the dentist and yet miraculously have never had a dental cavity," says Weyrich. "Those are the people that we've been recruiting as donors for oral microbiome transplantation."

Her team has conducted successful transplants in rats, but more work is needed before the technology can be applied to humans. One concern, for example, is that different populations of people have distinct oral biomes, so giving an Indigenous Australian person, for instance, a bacterium from a European might be ineffective or even harmful. There is also the question of how to grow the microbes that our ancestors had, many of which are no longer easy to come by.

Weyrich says we simply don't know what will happen if we take microbes that lived in the mouths of our ancestors and plonk them into a modern mouth – so we must proceed with caution. "It will be quite a puzzle to put it all together," she says. "But it's a puzzle we are really excited about tackling." ▮

Jasmin Fox-Skelly is a science journalist based in Cardiff, UK

KLAWE RZECZY

'We could be the first to meet the needs of everyone while reducing our footprint'

Climate change and biodiversity loss may seem like insurmountable problems, but data scientist **Hannah Ritchie** tells Alison George why she is cautiously optimistic that we can solve them

WITH constant headlines about floods, wildfires and record-breaking temperatures, it isn't surprising that many people think our current generation will leave the planet in a worse predicament than when we inherited it. But is that belief true? Hannah Ritchie doesn't think so. She is cautiously optimistic that we might be the first generation to pass on the environment in a better state than we found it.

She reached this counterintuitive conclusion after a decade digging into environmental records as a data scientist at the University of Oxford and lead researcher for influential online publication Our World in Data. In her new book *Not the End of the World*, Ritchie lays out the graphs that show the positive steps we have already taken to change our behaviour and mitigate climate change, from cutting coal use to shrinking carbon footprints. She talks to *New Scientist* about her growing conviction that we can solve the world's environmental problems and picks out some key trends that give her hope about us turning things around.

Alison George: I'm talking to you on a day when it was reported that online searches related to "eco-anxiety" have increased dramatically. Yet you study long-term environmental trends and are somewhat optimistic.

Hannah Ritchie: I still have anxiety and worry, but I think it's now paired with some sense of optimism that we can change things. The anxiety is completely justified and I get why people feel it. I feel it. But that feeling on its own is not that useful. You need to combine a sense of urgency and worry about the problem with a sense that you can actually do something about it.

One of the key messages in your book is that doom-mongering about the world's environmental problems isn't helpful.

The problem with the doom-and-gloom narrative is that it can lead people to a position where they feel like there's nothing that we can do about the problem. We need to make people aware of the issues – we're not going to make progress on climate change if no one thinks it's serious – but also combine that with a sense of optimism that we're capable of changing course and moving things forward. Some of the narratives around climate change only focus on the first part, just telling everyone this is how bad it is, and that doesn't actually lead us anywhere positive.

What makes you optimistic that we can turn things around?

Over the past decade, I've been trying to understand the world's environmental problems through data. What's clear is that we're not in a good place, we're heading towards some pretty severe crises. But we have seen progress over that time.

You only really get a sense of that when you step back to look at the data. Why I'm more optimistic now than I was a decade ago – which might seem strange given the recent record temperatures – is that I can see we're in a position where we have the solutions. I think the world's environmental problems are actually very solvable when, a decade ago, they were not. Then, I just couldn't really see any way forward where we could improve human well-being, reduce poverty and so on at the same time as keeping carbon dioxide emissions low. Now, I think we need to be cautiously optimistic.

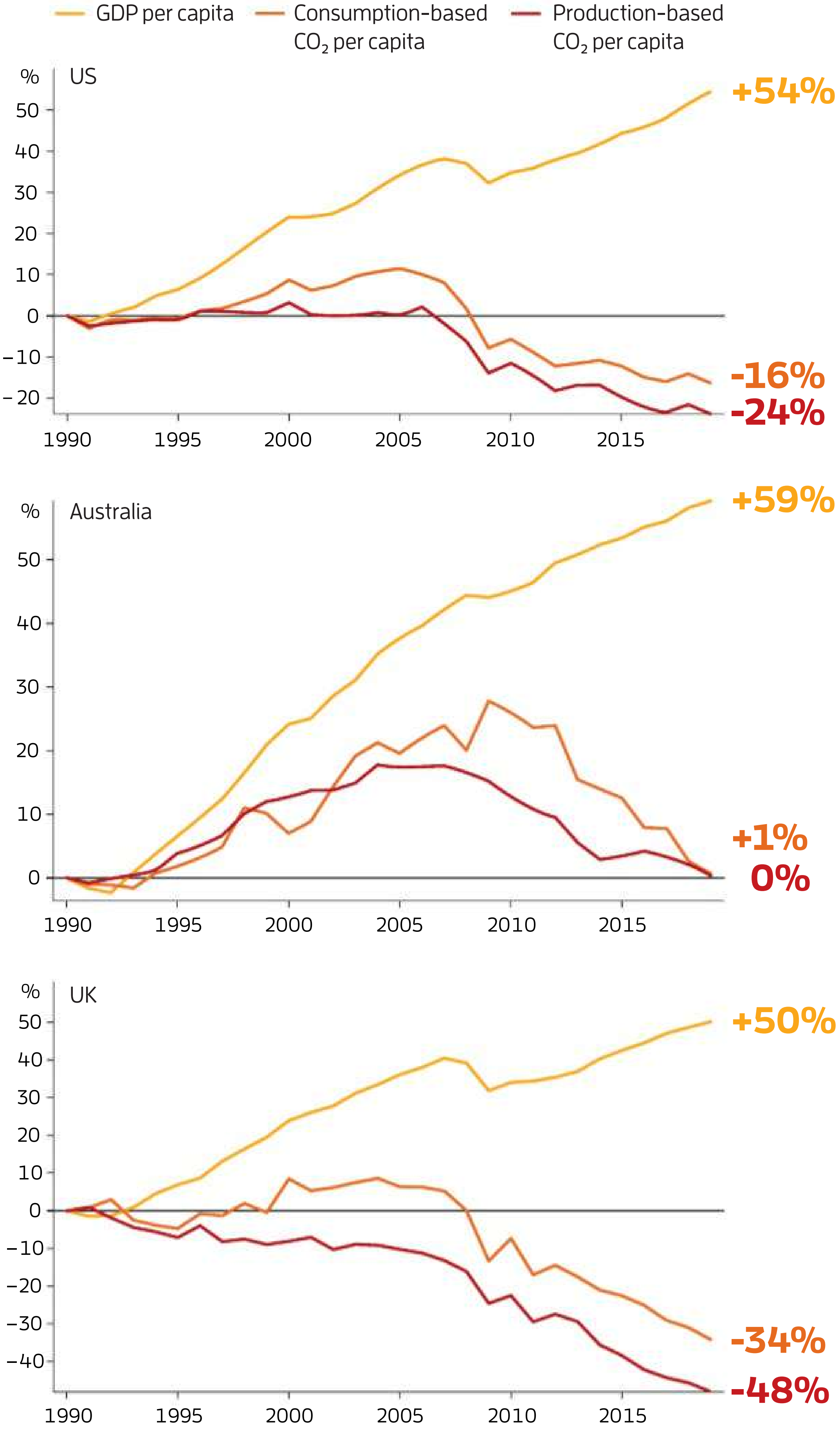
From looking at the data, what makes you feel we have some solutions to our climate problems?

If you go back to the signing of the Paris Agreement [on climate change] in 2015, the most expensive energy technologies were solar and wind. I couldn't see a way forward where countries would deploy them. Electric vehicles were totally out of reach. The technologies we needed to decarbonise were the most expensive ones.

Just 10 years on, and that's flipped. The dramatic fall in the prices of electric vehicles, as well as solar and wind energy, has completely changed the game. Solar and wind are now the cheapest and we are starting to see that countries are scaling them fast. For example, this year alone, China has deployed enough solar and wind to power the UK or France. ›

Many high-income countries have decoupled economic growth and CO_2 emissions

While GDP per capita has risen in countries like the US, UK and Australia since 1990, CO_2 emissions per person have declined



GDP has been adjusted for inflation. Consumption-based CO_2 per capita takes into account international trade and emissions from items produced offshore but consumed in-country, while production-based CO_2 doesn't. Land use change isn't included.

SOURCE: OUR WORLD IN DATA

You say in your book that one of the key improvements is that we are finally moving away from burning stuff to produce energy.

Yes, and this is fundamental for air pollution as well as the climate. We think of air pollution as a recent problem, but, in reality, it has been with us since humans discovered fire. When we burn stuff, whether it's wood or fossil fuels, we generate not only air pollutants, but carbon emissions. Now we're at the first point in history where we have the technologies to produce energy without burning anything at all. That's a very unique transformation.

Even so, we are on track to a warmer world...

If we had done absolutely nothing at all, we'd have been on a trajectory for the world to be at least 4°C warmer [than pre-industrial temperatures] by 2100. But a better comparison is to look at the trajectory we were on when we signed the Paris Agreement. Then, we were on a trajectory for between 3.5°C and 4°C of warming. We are currently on course for between 2.5 and 3°C.

Obviously, that's unacceptable and we need to move quickly to bend that curve downwards, but, even in the past decade, we have shaved around a degree off the trajectory that we were on. This notion that we've made no progress in the past decade is not true.

One of the points you make is that, historically, the richer you were, the more carbon dioxide you produced, but now we have broken that link.

It is true that rich countries tend to have higher emissions. But what's changed is that we're seeing what we call decoupling, where the rich countries have managed to reduce their emissions while growing their economies at the same time (see graphs, left).

This fundamental trade-off that we've had for most of human history – as you get richer, you inevitably emit more CO_2 – is starting to break down. Countries can reduce emissions without crashing the economy. This isn't just because they've offshored their emissions elsewhere, which is when a country moves its industry overseas, so that the emissions from producing those goods are allocated to the producing country, even if [those goods] aren't consumed there. They have managed to make their economies more energy efficient and to decarbonise their energy mix.

What is another trend that makes you feel optimistic?

Global carbon dioxide emissions per person peaked around a decade ago (see graph, right). However, total global emissions are still rising.

VCG/VCG VIA GETTY IMAGES

China deployed enough wind and solar in 2023 to power the UK or France

When do you reckon total emissions will peak?
I think it will be this decade. It's very hard to predict peaks and people will always get it wrong, but some people are suggesting that it could be this year or next year. A lot comes down to China, and there are suggestions that China's emissions could peak in the next few years. That would also mean that global emissions would peak in the next few years.

For me, one of the most fascinating graphs in *Not the End of the World* is one that shows how your carbon footprint is half that of your grandparents (see graph, page 38). How is that possible?
Two changes have happened. One is that our economies have become more energy efficient – we get more value from energy. TVs and cars are more efficient than they were in the past. But the big thing that's happened in the UK has been reducing coal. In the past, most of the UK's electricity was coming from coal – by far the dirtiest fuel, both in terms of carbon and air pollution. The use of coal to generate energy is also dying out in other countries, such as the US, Belgium and Spain. Today, China is the biggest emitter from coal, but its emissions per person are just a fraction of those of the UK and US in the past.

We have talked a lot about emissions, but what does the data show about species loss?
Biodiversity loss is a massive problem. One question I address in the book is whether we are in the middle of the sixth mass extinction. What's important to highlight is that species are going extinct at an alarming rate, higher than in any of the previous five mass extinction events. So, if you extrapolate that trend, you see that we are on course for a sixth mass extinction.

But what's different about the current situation, compared to the previous five mass extinctions, is that we are the handbrake. We can stop this. We have the solutions to maybe not eliminate biodiversity loss completely, but dramatically reduce it by tackling climate change and stopping deforestation. We can use much less land for farming.

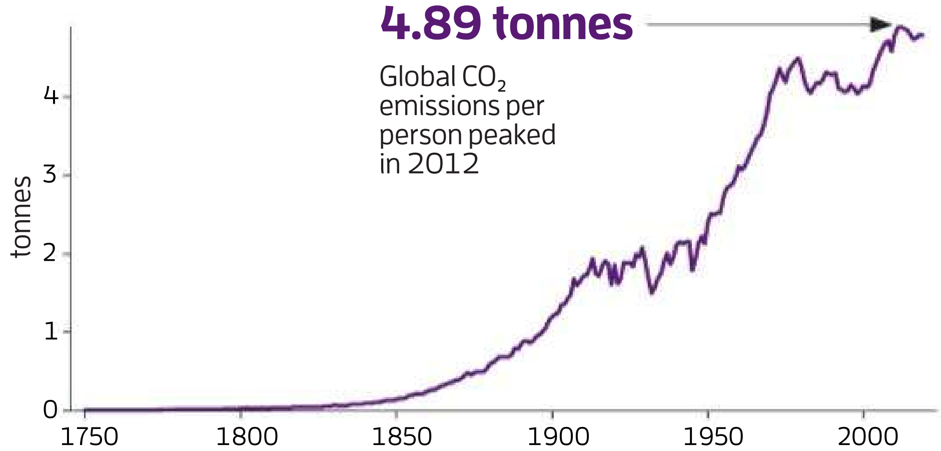
In your book, you come to a startling conclusion: we could be the first generation to leave our planet in a better state than we found it in. Really?
Historically, our ancestors did not have any option but to use environmentally damaging practices to progress. There was this trade-off: you either maintained poor living conditions for humans or you developed and reduced child deaths and reduced poverty, but with an increasing environmental impact. If you wanted more food, for example, your only option was to use more land or hunt more animals.

I think we could be the first generation that meets the needs of everyone – and that could eventually mean 9 or 10 billion people – and we can do that while reducing our environmental impact. We have the opportunity to be the first generation that achieves both of these goals at the same time.

In agriculture, we now have alternative technologies to produce meat and much higher crop yields, so we can use less land and have less deforestation. The same applies to energy. Energy sources of the past involved either cutting down wood or burning fossil fuels. We are the first generation in history that can produce energy without burning stuff. ›

Global CO_2 emissions per person have peaked

Excluding land-use change, per person emissions peaked in 2012

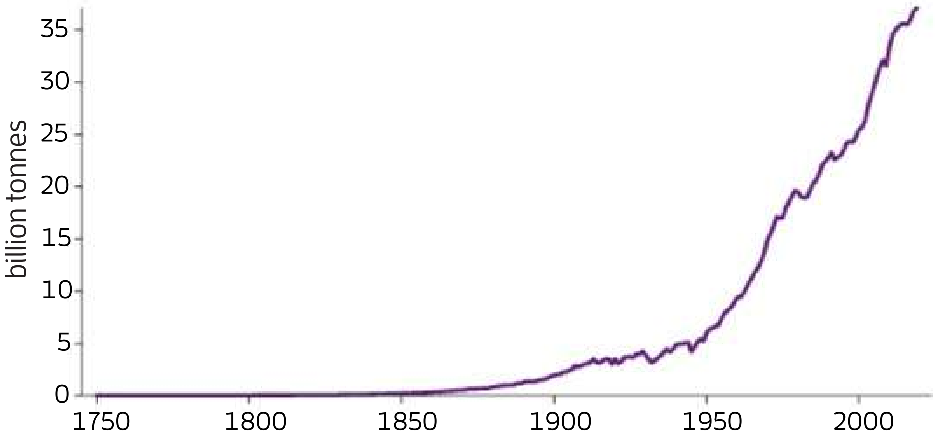


4.89 tonnes

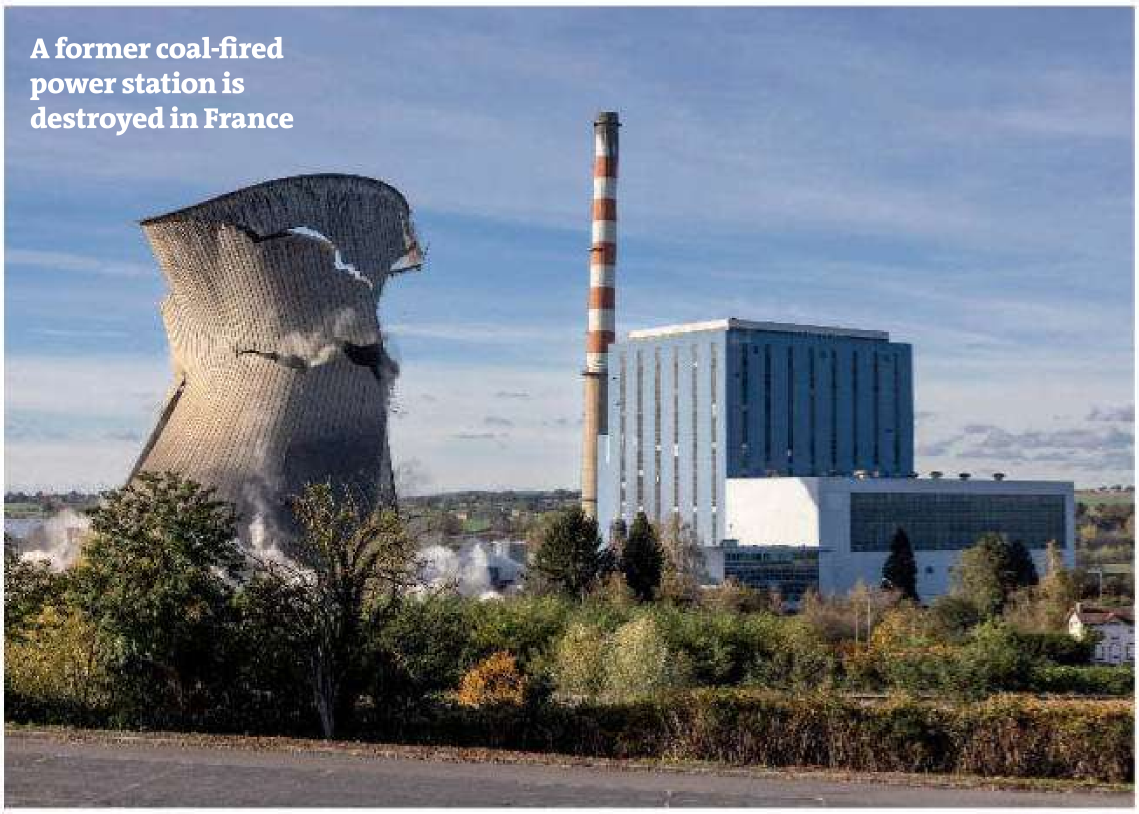
Global CO_2 emissions per person peaked in 2012

SOURCE: GLOBAL CARBON PROJECT; UN POPULATION DIVISION

...while total global CO_2 emissions are still rising



SOURCE: GLOBAL CARBON PROJECT

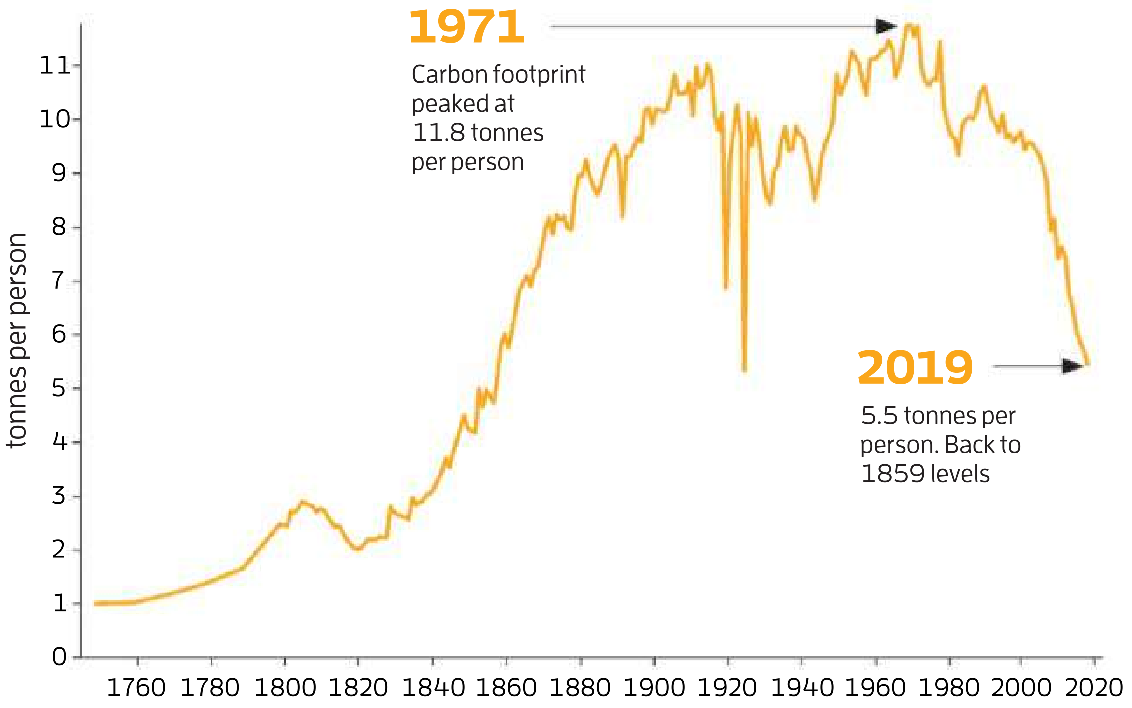


A former coal-fired power station is destroyed in France

ARNAUD FINISTRE/AFP VIA GETTY IMAGES

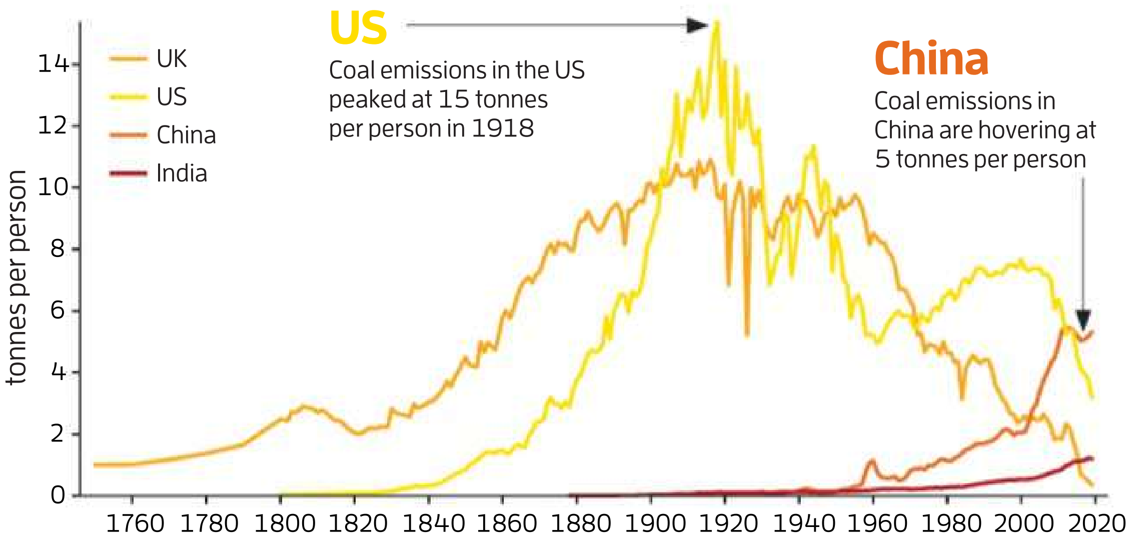
Carbon footprint in the UK is declining

Per capita CO_2 emissions are falling, mainly due to a drop in coal use



SOURCE: GLOBAL CARBON PROJECT; UN POPULATION DIVISION

CO_2 emissions from coal per person are falling



SOURCE: GLOBAL CARBON PROJECT; UN POPULATION DIVISION

For you, this is linked to a different way of thinking about sustainability.

Sustainability is basically not degrading the environment. That's the traditional definition, and I think that's fine. But the reality is that we also want to live well and to reduce human suffering. So, to me, sustainability is this two-pronged goal of providing a good life for everyone and having a low environmental impact.

In the book, you make the controversial claim that humans have never lived sustainably. What do you mean?

You could argue that there are many generations that had a low environmental impact. That's certainly true. But the reason they had a low environmental impact was often that the populations were really small, and this was because child mortality was very high. For most of human history, you had around half of children dying before reaching puberty. That's why you didn't have growing populations.

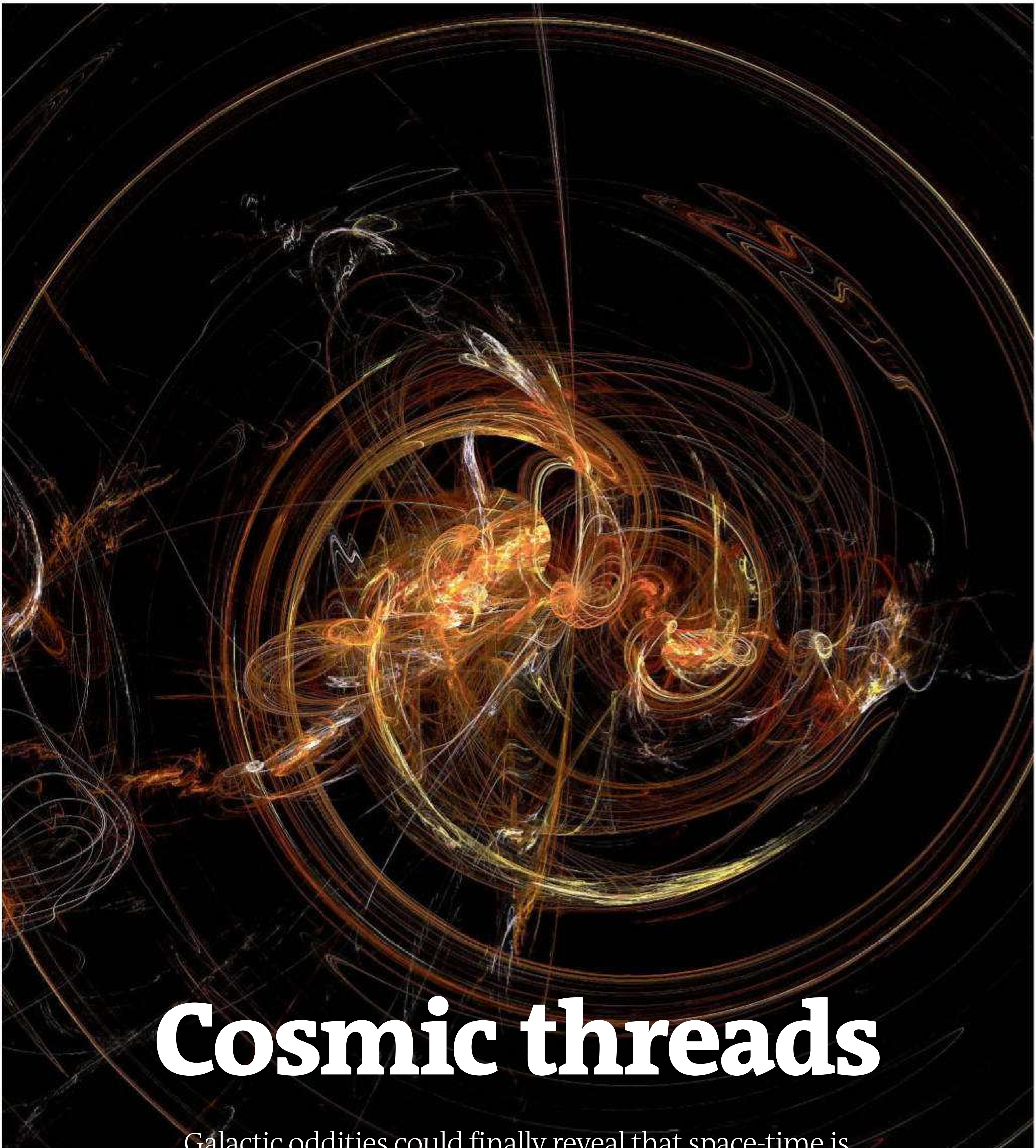
So I think that comes back to what our definition of sustainability is. To me, we want to reduce human suffering. Having half of our children die is not doing that. In the past, environmental impact was low, but human suffering was high and our living standards were low. Over the past few centuries, we've gone the other way. Human well-being has improved, but we're now facing lots of environmental crises.

What can we, as individuals, do to make a difference?

Lots of people have good intentions, they want to make a difference. What I think is important is that we put that energy in the right places. There are a range of things that people think have a big impact but don't, such as how you choose to wash your dishes.

I use the example of going to the supermarket. Everyone focuses on the plastic bag, when what they should be focusing on is what they are putting in the bag. Most of your environmental impacts come from the food you eat not the plastic bag that you take to the shop. Similarly, if you ask people what they are doing to help the environment, they tend to see recycling as top of the list. But in terms of impact, it's the bottom. ▮

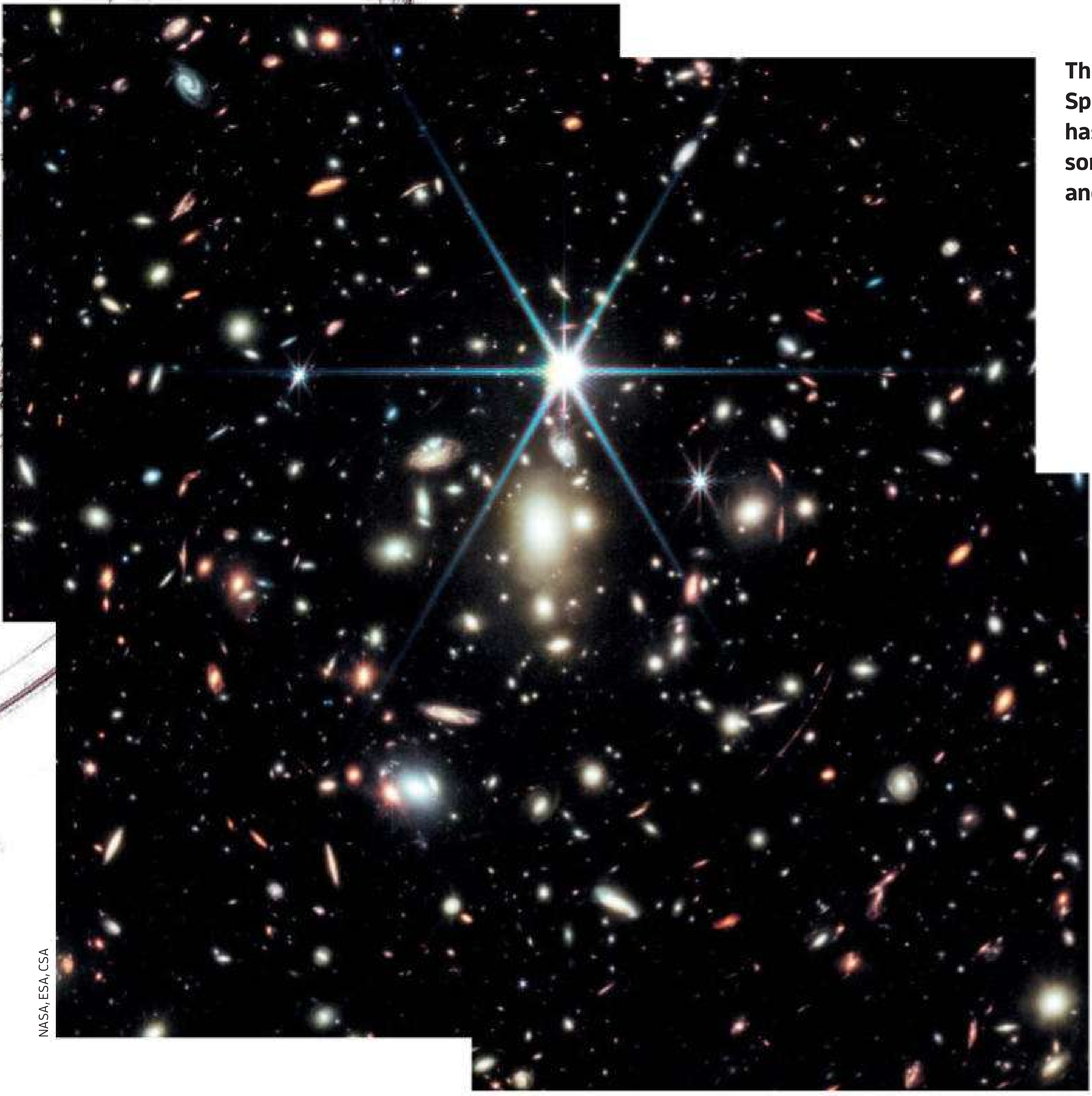
Alison George is a features editor at *New Scientist*



Cosmic threads

Galactic oddities could finally reveal that space-time is shot through with gossamer-thin threads of extreme energy produced in the big bang, says **Dan Falk**

R3BV/SHUTTERSTOCK



The James Webb Space Telescope has spotted some puzzling ancient galaxies

NASA, ESA, CSA

HOW long is a piece of string? In this case, as long as the entire universe is wide. But then cosmic strings aren't your average twine. Thinner than a proton and stretching for billions of light years, they would propagate through space at nigh-on the speed of light, fuelled by – and containing – the barely imaginable energies that existed at the big bang, where they originated.

Or at least that's the idea. Cosmic strings are among the most extreme phenomena theorists have ever dreamed up, and yet there are sound reasons to consider them. They are "one of the most plausible, testable predictions of unified theories", says Neil Turok, a physicist at the University of Edinburgh, UK – referring to theories that seek to describe how the fundamental forces of nature were merged, and then diverged, in the very early universe.

We are yet to find any clear evidence for the existence of cosmic strings. But in the past year, astronomers have spotted a slew of anomalies – from inexplicably large galaxies to strangely shaped clusters – that suggest we may finally be within touching distance of these enigmatic threads. What's more, if one of these hints does hold up, we now have the tools to confirm the existence of cosmic strings once and for all, and even to begin distinguishing between their different forms.

That would count as an "enormous" breakthrough, says Joseph Conlon at the University of Oxford, as it could help theorists decide between the various unified theories on the table. "It would be a fundamentally new constituent of the universe," he says.

Our best description of the known particles and forces in nature, the standard model of particle physics, doesn't lead to cosmic strings. However, many enduring puzzles, such as the nature of dark matter – which seems to glue galaxies together – or the unusual shape-shifting behaviour of elusive particles called neutrinos, has led theorists to look for extensions to the standard model. And cosmic strings do naturally pop out of many of these extended versions, broadly classed as quantum field theories – which depict particles as excitations in a background field rather than as the discrete entities we are used to. In that sense, cosmic strings, though at first glance exotic, are quite banal to those seeking a more complete mathematical description of nature.

Generally speaking, these alternative theories of particle physics imagine that at the beginning of the universe, three of the forces of nature – electromagnetism and the strong and weak nuclear forces – manifested as a single force before separating. As the cosmos cooled, this unified quantum field underwent a sudden "phase transition", a bit like the one that happens when water freezes into ice. Like the natural cracks that appear in ice cubes, similar defects, in the form of one-dimensional strings, could have occurred as the unified field gave way to its constituent parts.

Confusingly, there is another category of cosmic strings that might exist. These "cosmic superstrings" are related to superstring theory, which hopes to unite the two disparate pillars of modern physics – quantum mechanics and general relativity – into a theory of quantum gravity. In superstring theory, everything in the universe is made of minuscule one-dimensional vibrating strings. These aren't in themselves cosmic strings. However, if some of these strings were blown up to cosmological scales by inflation, a period of sudden expansion early in the universe's history, they would have become cosmic superstrings.

Galactic oddities

With so many different theories manifesting cosmic strings, what they would look like today is very much up for grabs. Some would stretch across the observable universe, with ripples of energy travelling along them at close to the speed of light so that they kink and fold into a tangled web. When the strings collide with each other or folded back on themselves, smaller string loops would break off. These loops could also intersect with themselves, breaking off even smaller loops that would add to the jumble.

If this network does exist, however, it should leave its mark on the cosmos by tugging on anything else that has mass. For example, when cosmic strings were first imagined in 1976 as an extension to the standard model, by Tom Kibble at Imperial College London, they seemed to offer an explanation of how galaxies and clusters were seeded in the early universe. The idea was that matter would naturally have been drawn to the intense gravity of cosmic strings, setting off a cascade of structure formation in the early universe, as matter merged and clumped together.

However, in the early 1990s, cosmic strings fell out of favour among theorists. When physicists measured the ancient radiation left over from the early universe, known as the cosmic microwave background (CMB), they found that it was very smooth – varying only very slightly across the entire sky. This didn't fit with the idea that cosmic strings account for a large part of the universe's energy. To take a rough analogy, if the surface of a swimming pool is still, you can be pretty sure there is no orca or manatee throwing its weight around down below.

The CMB's smoothness means that, at most, a tenth of the universe's energy is wrapped up, so to speak, in these cosmic string structures.

"THESE FLATTENED GALAXIES ARE HARD TO RECONCILE WITH THE STANDARD MODEL OF COSMOLOGY"

"They can't have been the dominant disturbance that caused the formation of galaxies," says Jim Peebles, a cosmologist at Princeton University. "But they could still be there, and may be detectable, if you look closely enough."

Peebles is encouraged by some unusually shaped galaxy clusters he identified in a paper published in August. Even if cosmic strings had little impact on the overall distribution of galaxies today, individual strings could still have deformed individual clusters of galaxies. Imagine a cosmic string cutting through a spherical galaxy cluster like a piece of cheese wire that moves at almost the speed of light. The string's gravity would distort the cluster, leaving a somewhat-skewed hamburger shape in its wake. "This slight flattening would be common to a large region of space, so you'd look at a lot of galaxies and see if there was any tendency to form one of these sheets," he says.

Hints of a flat pattern among galaxies near our own had been noted since the 1950s, but recent astronomy surveys have made the case stronger. In his paper, Peebles writes that an analysis of two distinct groupings of galaxies appears to show the requisite squishing. Each cluster, one of which contains our own Milky Way, is about 30 times as long as it is wide.

This flattening, Peebles argues, is hard to reconcile with the standard model of cosmology used to explain the structure of the universe, known as the lambda-CDM model – the Greek letter lambda denoting

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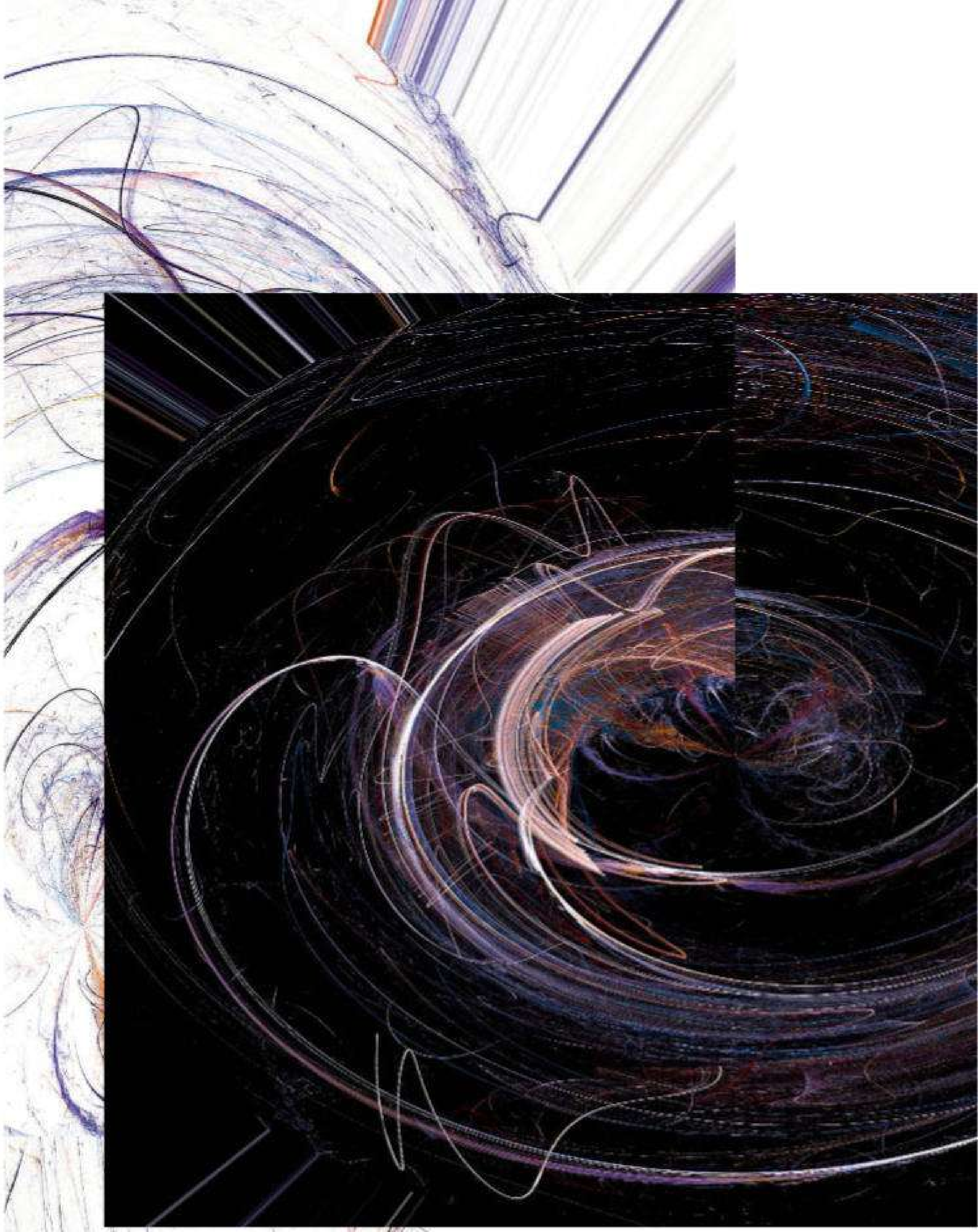
The SKA telescope array could find evidence for cosmic strings

CSIRO

the hypothetical force that is thought to be accelerating the expansion of the universe, and CDM being cold dark matter. If the finding holds up, Peebles argues, "thoughts will turn to the passages of long, nearly straight cosmic strings".

New observations of ancient galaxies offer further hints of cosmic strings, as their power to pull matter together could explain how such galaxies grew so quickly. In February, the James Webb Space Telescope (JWST) spotted a handful of surprisingly massive galaxies that formed only 500 million to 800 million years after the big bang, an observation that also challenges the lambda-CDM model. The smoothness of the CMB means that cosmic strings can't be the main driver of galaxy formation, but they can still have some clout, says Robert Brandenberger at McGill University in Montreal, Canada. "If you have an additional source of structure formation, which cosmic strings can provide, then you can help the situation," he says.



Cosmic vibrations

With this in mind, Brandenberger calculated what impact lightweight strings could have had in the early universe. These have a small mass per unit length – at least by cosmic string standards – which means they have no noticeable effect on the CMB. Yet their gravity is still potent enough to explain the smattering of very large galaxies seen by JWST.

Theorists expect cosmic strings to have their greatest influence on structure formation closer to the big bang, when the string network would have been more tightly woven. That means the best evidence will be found in the very oldest galaxies, says Brandenberger. He plans to study their structure via the radio waves emitted by cold, neutral hydrogen atoms, known as 21-centimetre radiation, in galaxies born a mere 50 million years or so after the big bang. This radiation should become clearly visible when the Square Kilometre Array of telescopes in South Africa and Australia switches on in the late 2020s. "I'm most excited right now about 21-centimetre," says Brandenberger.

Astronomers pointed to another potential hint of the presence of cosmic strings in September – two galaxies that appear, to some observers, to be mirror images of each other. The idea is that a cosmic string that happens to fall in between Earth and a distant galaxy could distort or duplicate the image of a single galaxy by gravitational lensing, whereby a very massive object can bend light around it. So one galaxy could appear as two identical ones. Brandenberger, however, is sceptical. "There were already two similar claims, and in both cases the 'double images' turned out to be two different objects which we see in the sky as close [together]," he says. Moreover, gravitational lensing can be caused by other very massive objects, such as lumps of dark matter or black holes, so a mirror image isn't a sure sign of a cosmic string.

The trouble with all these proposals is that there are equally plausible explanations. With so much still unknown about the complicated dynamics of galaxies, cosmic strings remain an outside possibility. But there is another way in which cosmic strings may reveal themselves, possibly offering theorists richer data with which to untangle their origins. In June, the North American Nanohertz Observatory for Gravitational Waves (NANOGrav), an international collaboration, discovered a background hum of gravitational waves,

> "COSMIC STRINGS WOULD HAVE THEIR GREATEST INFLUENCE CLOSER TO THE BIG BANG"

SHUTTERSTOCK/TANYALOVUS

> “IMAGINE THAT YOU FIND THE STRINGS OF STRING THEORY ARE REALLY THERE, SNAKING ACROSS THE ENTIRE UNIVERSE”

which appears to be coming equally from all directions in the sky. It uses radio waves emitted by rotating neutron stars, or pulsars, as a way of detecting the slight distortions caused by passing gravitational waves, which subtly change the pulsar signals.

The leading candidate for this background hum is widely thought to be gravitational waves resulting from countless collisions of supermassive black holes scattered about the cosmos. That explanation is favoured on the grounds that we know such black hole binaries exist as a result of galaxy mergers. “If you bet on familiar astrophysics,” says Conlon, “you will win 99 per cent of the time.”

But cosmic strings, which are constantly bending and vibrating due to the tension held in them, would also emit gravitational waves. There is an outside chance that cosmic strings are responsible for the background hum, says Turok, who was one of the first researchers to investigate the physics of cosmic strings back in the 1980s. The problem is that the NANOGrav signal itself is very weak. “The jury is still out” as to whether it is even a real signal, says Turok, who is watching with interest as NANOGrav’s data becomes clearer.

In particular, he will be keeping an eye on whether the “spectrum” of the background hum has a hallmark slope that can only be explained by cosmic strings. In this case, the strength of the gravitational waves should increase in proportion to their wavelength. “Cosmic strings would make a very specific prediction of how the signal increases as you go to longer and longer waves... that’s exciting,” says Turok. However, he expects that another decade of data collection would be needed in order to see any such correlation.

Quantum gravity

Turok also cautions that calculating the cosmic string spectrum in detail has proven “much harder than people expected”. That is partly because the exact shape of the strings is unknown. As strings collide with each other and pinch off loops, they can end up “quite jagged on small scales”, he says, which makes the computations more challenging.

Cosmic strings discovered via gravitational waves could also offer a glimpse into the nature of the strings themselves. “All cosmic strings wiggle in roughly the same way, but the rate [at which energy reduces in] the wiggles is different for different species of string,” says Turok. For example, cosmic superstrings, made when the strings from string theory inflate, would lose energy as they decayed into exotic particles. They would also be less prone to getting chopped up into loops than the cosmic strings made from phase transitions in the very early universe. This is because string theory has extra dimensions that the strings wiggle around in, making them less likely to cross. All of which would affect the strength and form of the gravitational wave signal. Again, though, the actual calculations are proving to be fiendishly difficult, says Turok.

If experimentalists can pull off such a measurement, it would offer a rare observational test of unified theories of nature – including, perhaps, clues about the long-sought quantum theory of gravity. These unified theories would only reveal themselves at enormous energies, beyond the reach even of the Large Hadron Collider. “It would provide an absolutely unique insight into extremely high-energy physics, well beyond any other observation,” says Turok.

Theorists, meanwhile, have been working to see what sorts of fundamental theories are consistent with cosmic strings. In a paper published in June, for example, Astrid Eichhorn at the University of Southern Denmark found that a class of quantum gravity theory, called “asymptotically safe” theories, can’t accommodate cosmic strings made by some extensions to the standard model of particle physics. Theorists prefer symptotically safe theories because they connect to these extensions in a self-consistent way that doesn’t lead to infinities. This might sound like bad news for the existence of cosmic strings, but Eichhorn says observations must lead the way. “If there was a strong discovery of cosmic strings, that would spell trouble” for these extensions, she says.

This would also be taken as a hint that cosmic superstrings are more likely to exist than kinds of cosmic string emerging from extended models of particle physics. “If cosmic strings existed that were actually blown-up superstrings, then clearly this would help us understand quantum gravity,” says Conlon. “It’s a big ‘if’ though!”

For Conlon, discovering cosmic superstrings would be like winning the lottery. “All these years, we’ve been thinking how to connect string theory to any kind of experiment or observation,” he says. “[Imagine] that you then find that the strings of string theory are really there, snaking across the entire universe.” ▮

Dan Falk is a science journalist based in Toronto, Canada. His books include *The Science of Shakespeare* and *In Search of Time*

The back pages

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A cartoonist's take on the world p47

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Twisteddoodles for *New Scientist*
Picturing the lighter side of life p48

60-second psychology

The art of small improvements

Rather than making ambitious New Year's resolutions, try embracing the concept of kaizen, says **David Robson**

David Robson is an award-winning science writer and the author of *The Expectation Effect: How your mindset can transform your life*

AFTER our joyful revelling comes the inevitable season of good intentions. When we make our New Year's resolutions, we often set ourselves ambitious goals – to run a half-marathon, learn a language or write a novel. One reason these resolutions often fail is that our focus is too wide – we think about the reward at the end of the journey, not considering the little steps that we need to take to get there. Then we end up feeling defeated and dejected as we fail to make the progress we want.

Perhaps we should all try to apply the Japanese concept of kaizen instead. I first came across the term in Anna Katharina Schaffner's fascinating new book *Exhausted*, out on 18 January, which guides us through the causes of burnout and how to avoid it. Kaizen, Schaffner explains, translates as "change for the better" and encapsulates a philosophy of continuous and incremental improvement. If we practise kaizen, we should concentrate on the small wins that will slowly add up to bigger successes, rather than hoping for a sudden transformation that almost never works. Schaffner argues that this emphasis on gradual change prevents our good intentions from adding more stress to our lives, while still leading us to our goals.

PARRADEE KIETSIRIKUL/GETTY IMAGES

Her descriptions of kaizen reminded me of research on the "strategic mindset". Some people continually look for tiny improvements in their methods. They are constantly asking themselves "Is there a better way of doing this?" and "What can I do to help myself?". If you already have a strategic mindset, this may sound obvious, but the research shows that many people fail to do this. Instead, they put in a lot of effort without ever checking to see if they could change their practices to be more efficient, which saps their energy without bringing much progress.

Consider my own 2023 resolution of becoming more fluent in Spanish. I have been quite dedicated, listening to podcasts in the language and using flashcards. But when I recently tested myself on what I had studied earlier in the year, I had forgotten about 90 per cent of the words. If I had had a more strategic mindset – if I had practised kaizen – I might have listened to fewer podcast episodes but made sure to spend more time revisiting previous lessons. From week to week, I might not have noticed much difference. But over the year, this one small change to my methods would have paid huge dividends for my fluency.

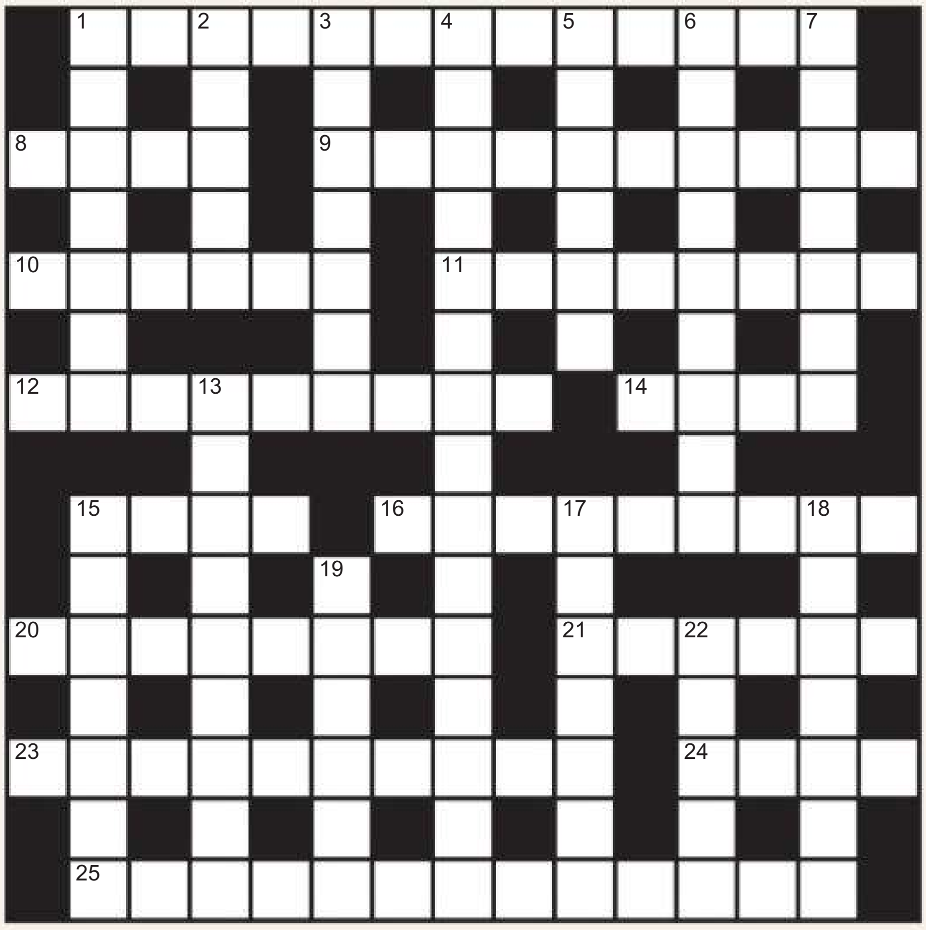
The principle of kaizen could be applied to any area of our life that we would like to improve. "If we want to change our working patterns, we can commence by identifying one small habit that is not serving us and concentrate our efforts on that," writes Schaffner. This is the kind of resolution I will be making next year. ▮

60-second psychology appears monthly

Next week
Stargazing at home

These articles are posted each week at newscientist.com/maker

Quick crossword #148 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

1 Informed speculation (8,5)
8 Sibling produced in the same pregnancy (4)
9 Wind-speed measurement device (10)
10 Number of degrees in a right angle (6)
11 Forest canopy (8)
12 Build afresh (9)
14 1/8760th of a year (4)
15 Blockage (4)
16 Mg (9)
20 Antibiotic discovered in 1949 (8)
21 Nerve cell (6)
23 Involving the transmission of light pulses through fine cables (5-5)
24 Computer operating system developed by AT&T (4)
25 Plague outbreak of 1346–53 (3,5,5)

DOWN

1 Apollo 1 astronaut (2,5)
2 Arm bones (5)
3 Scrutinise methodically (7)
4 ___ induction, phenomenon discovered by Michael Faraday in 1831 (15)
5 Hollow formations inside rocks (6)
6 Subatomic particles (9)
7 1973 sci-fi comedy starring Woody Allen (7)
13 Online trading (1-8)
15 Marie Curie or Dorothy Hodgkin, for example (7)
17 Alkaline, perhaps (3-4)
18 Bladder stone (7)
19 Group of fish swimming together (6)
22 Appendage at the back of the palate (5)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #232
set by Bethan Ackerley

1 The three parts of the hip bone are the ischium, the pubis and what?
2 One of the earliest written uses of the word "cryptograph" is found in which Edgar Allan Poe story?
3 In what year did the Carrington event, the most intense geomagnetic storm in recorded history, take place?
4 What name is given to organisms that thrive in environments with very few available nutrients?
5 In 1952, which two scientists used an axon from a longfin inshore squid to demonstrate the ionic mechanism of action potentials?

Answers on page 47

Headscratcher
set by Zoe, Rob, Brian and friends
#255 Final light bulb moment

The Headscratcher team sat brainstorming ideas for the final problem in this iteration of *New Scientist*'s puzzle column. "We should probably give it a seasonal flavour," said Brian. "Something about festive decorations?" said Rob.

"We could base it on the eight lights on my mantelpiece," said Zoe. "I've programmed the one on the left to blink on and off every second. Each of the other lights also switches state every second, but only when all the lights to the left of that light are on."

"Sounds complicated," said Alison. "Not really," said Zoe. "After 1 second, light one switches on. At 2 seconds, light two switches on and light one switches off. At 3 seconds, light one switches on and light two stays on. Then light three switches on for the first time and the other two switch off, and so on."

"So, from the starting position of no lights being on, how many seconds is it before all eight lights are lit?" asked the others.

And that, dear reader, is the final puzzle in the Headscratcher column. Watch out for *New Scientist*'s new puzzle column, BrainTwister, starting next week.

Solution next week

Bubbling up

Does putting a teaspoon into an open bottle of champagne really prevent it from losing its fizz, and if so, why?

Mark Thompson
Tewkesbury, Gloucestershire, UK
Placing a teaspoon handle down into the neck of an open bottle of champagne is a common hack to help preserve its fizz.

The idea behind this method is that the spoon, due to its metal composition and its handle's cooler temperature, can help maintain carbonation by reducing the escape of carbon dioxide bubbles from the champagne.

However, the scientific evidence supporting this method is limited. It is possible that the spoon acts as a barrier, preventing immediate CO_2 release, but it may not significantly affect the champagne's fizz over an extended period.

The most effective way to preserve champagne or any carbonated drink's fizziness is to reseal it with an airtight stopper and then store it in the refrigerator.

> "The spoon makes no difference. This question has become an urban legend and shows how easy it is to be misled"

SHUTTERSTOCK/CHRISCHIPS

How often do animals make mistakes, and are some more prone to errors than others?

This week's new questions

Oops I did it again **Humans make mistakes, but how often do other animals? Are some more prone to errors and do they learn from them?** ***Christian Digby-Firth****, Dorchester, Dorset, UK*

Weighty matter **How heavy is Earth and how much weight could it sustain before caving in?** ***David Gibson****, Canterbury, New Zealand*

Damir Blazina
Chester, UK
The spoon makes no difference. This question has become an urban legend and shows how easy it is to be misled by an uncontrolled experiment. People observe that their half bottle of champagne with a spoon in the neck is still fizzy the following morning, but, in reality, a champagne bottle keeps its fizz for several days with or without the teaspoon.

The bubbles in champagne and other sparkling wines are CO_2. In traditional *méthode champenoise* production, the wine undergoes two fermentations: one before bottling and one in the bottle. The second fermentation produces the bubbles that are vital for the flavour of the final product.

The process produces some 7.5 grams of CO_2 in an average 0.75-litre bottle of champagne. Because the bottle is sealed, the gas dissolves in the wine to reach an equilibrium with the (very small) headspace above it and leads to quite a high pressure in the bottle: about 6 bar (90 psi) for champagne, somewhat less for other sparkling wines. This is why champagne bottles are so thick.

When the bottle is opened, the gas in the headspace can expand into the atmosphere, giving its characteristic "pop". The dissolved CO_2 can now escape from the wine, eventually reaching a level that matches the amount in the atmosphere, of about 1.3g in a 0.75-litre bottle. The bubbles are a sign of this process, which isn't instantaneous: its rate depends on the ambient temperature and the surface area of the liquid that is in contact with the atmosphere. For a champagne bottle with a narrow neck at room temperature, it takes several days. A bottle of champagne opened in the evening will therefore still be bubbly the next morning, and probably for three to four days after that.

The spoon in the neck makes no difference, as can be shown by storing two open bottles, one with and one without a spoon. More reliable ways to limit the loss of bubbles include refrigeration to slow down this process, and using a sparkling wine stopper that prevents the CO_2 from escaping the bottle and recreates the equilibrium between the liquid and the headspace above it, causing the gas to re-dissolve.

For more detail, I can refer your readers to *New Scientist*'s book *How to Fossilise Your Hamster* (2007), which addresses the question on page 28 and details a controlled experiment to prove that the spoon has no effect. I would only add that those of us fortunate enough to be of legal drinking age in our respective jurisdictions can (responsibly) enjoy the sparkling wine throughout the study – not something that every chemistry experiment can offer!

David Muir
Edinburgh, UK
No, it doesn't. In fact, the wine may lose its fizz even faster, as scratches and pits on the surface of the spoon will increase the number of nucleation points in contact with the wine. Nucleation points are tiny surface aberrations that cause the gas within drinks to be released more easily. Look at any glass of fizzy drink and you will see streams of bubbles originating from particular spots on the glass – these are nucleation points.

This question begs another: why open a bottle of champagne if you aren't going to finish it?

Left or right

Why aren't we equally capable with our left and right sides? Wouldn't this have given us a survival advantage?

Tony Seikel
Inkom, Idaho, US
Non-humans also demonstrate laterality of function, in which one side of the body has different "specialisations" than the other.

This lateralisation occurs because brain areas responsible for

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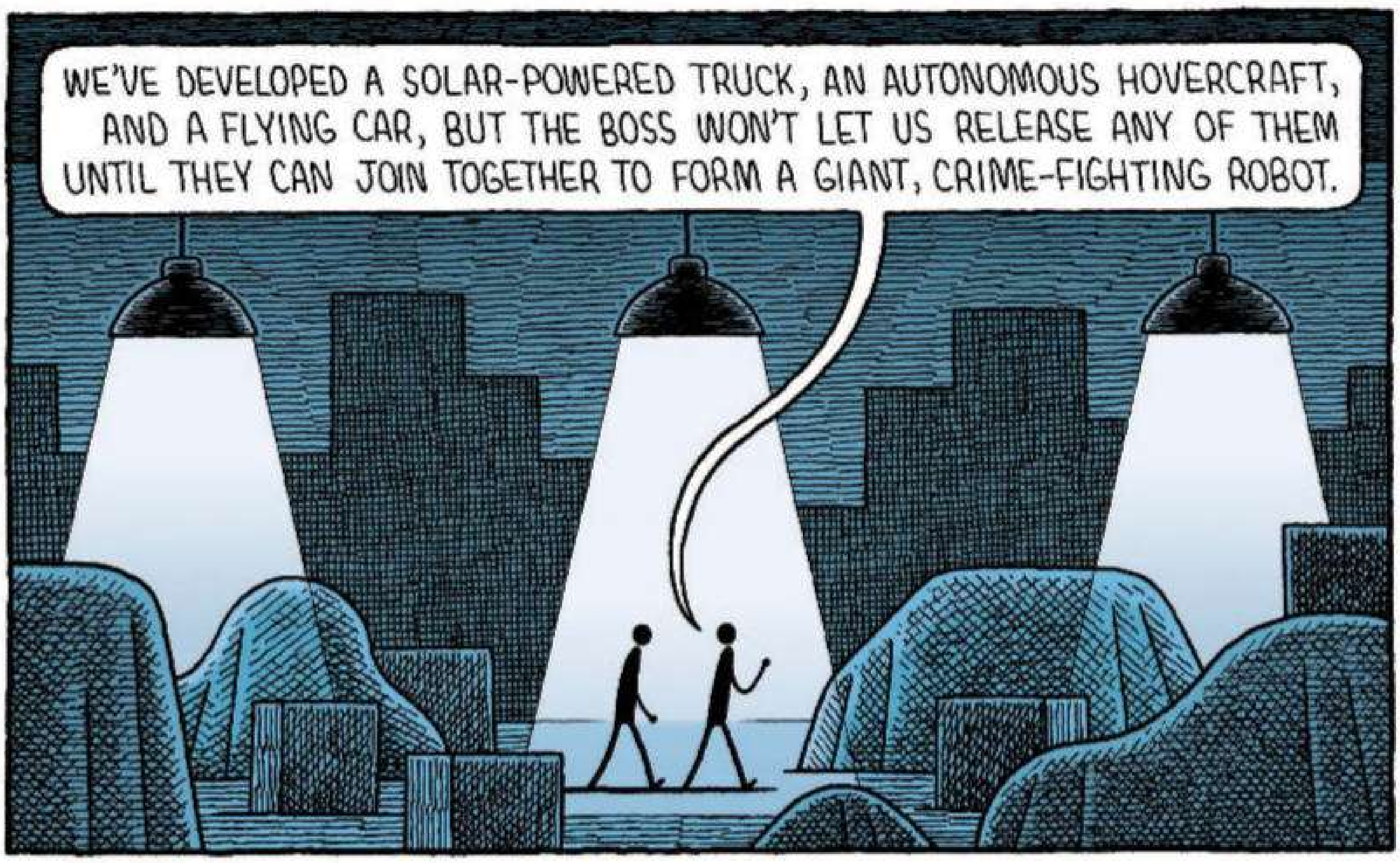
Tom Gauld
for New Scientist


WE'VE DEVELOPED A SOLAR-POWERED TRUCK, AN AUTONOMOUS HOVERCRAFT, AND A FLYING CAR, BUT THE BOSS WON'T LET US RELEASE ANY OF THEM UNTIL THEY CAN JOIN TOGETHER TO FORM A GIANT, CRIME-FIGHTING ROBOT.

those activities are specific to one hemisphere or another. We talk about "hemispheric dominance" in the sense that, for instance, the left brain hemisphere in 85 per cent of humans governs language and fine-motor function. While one hemisphere may be dominant in a specific task, that hemisphere has come to be seen as generally dominant, such that we often think of the left hemisphere as dominating (and therefore being "better" than) the right. This translates into an unspoken sense of hemispheric superiority.

In humans, as well as fine-motor and language function, the dominant hemisphere controls many important cognitive functions, such as categorisation and linear analysis. In contrast, the non-dominant hemisphere has responsibility for integrating and synthesising the activities and processes of the dominant hemisphere. For instance, the dominant (typically left-hemisphere) fusiform gyrus, a structure of the brain, can identify and label all the parts of faces, but the fusiform gyrus in the non-dominant (typically right) hemisphere is apparently responsible for putting them together to make a recognisable face. Without the non-dominant hemisphere, the dominant side knows and can list off the parts, but can't make sense of the whole.

> **"In hemispatial neglect, the individual isn't aware of the presence of the left half of their body until it is brought to their attention"**

And it is more than "can't make sense of the whole": those who work with people who have had a non-dominant-hemisphere stroke know that those who have "normal" left-hemisphere function and a disordered right hemisphere can have wide-ranging conditions, including not realising they can't make sense of the whole, and not even realising something is wrong.

These are collectively referred to as misidentification syndromes and include deficits in spatial awareness (hemispatial neglect), and significant language and reading conditions related to the lack of the availability of context provided by the right hemisphere.

In hemispatial neglect, the individual is simply unaware of the presence of the left half of their body (left neglect) or the left visual field until it is brought to their attention. Once their attention flags, that portion of their body or visual field is no longer available to consciousness. It is possible that contextualisation itself is an evolutionary benefit derived from differentiation of function, in that it complements and supports the more active processes.

To come back to the question, we have a cultural assumption that doing (dominant side) is important and being (non-dominant side) is less so. The availability of a synthesising system to complement the dominant doing side may have given us a competitive advantage in itself. We are, after all, human beings, not "human doings"! ▮

Answers

Quick quiz #232
Answers

1 The ilium
2 *The Gold-bug*
3 1859
4 Oligotrophs
5 Alan Hodgkin and Andrew Huxley

Cryptic crossword #125 *Answers*

The theme words, marked with an asterisk, are SI units

ACROSS 1 Raceme, **4** Aboard, **8** Muff, **12** Donations, **13** Becquerel*, **14** Sievert*, **15** Lumen*, **16** Sedan, **17** Obama, **19** Unwanted, **21** Stat, **24** Mountain bike, **27** Radian*, **29** Kelvin*, **30** Grain alcohol, **33** Lute, **34** Ornament, **36** Latex, **39** Garum, **41** Tesla*, **43** Sojourn, **46** Anthelion, **47** Occlusion, **48** Mole*, **49** Second*, **50** Newton*

DOWN 1 Rides, **2** Candela*, **3** Metre*, **5** Basil, **6** Albumen, **7** Decanter, **8** Mousse, **9** Farad*, **10** Volt*, **11** Plankton, **17** Ohm*, **18** Attain, **19** Unit, **20** Weber*, **22** Thigh, **23** Pascal*, **25** Unlit, **26** Knife, **28** Watt*, **29** Kilogram*, **31** Lux*, **32** Proteins, **35** Arsenic, **37** Tourist, **38** Ampere*, **40** Ratio, **42** Acorn, **43** Sick, **44** Joule*, **45** Ninon

NYE adventures

Happy New Year to ears, noses and throats – and to the people who minister to them!

Julia Werz at Ulm University Hospital, Germany, and three colleagues began the celebration early, publishing the study “New Year’s Eve in otorhinolaryngology: A 16-year retrospective evaluation”.

That celebration comes in three parts. First, a sketch of 16 years of adventures on New Year’s Eve in the otorhinolaryngology department of a single hospital. Simply put: “Pyrotechnics are a long-standing tradition at the turn of the year.”

Next, a collection of minute sketches of the different kinds of adventure. Of the New Year’s Eve-associated emergency presentations: “72% were male, 15.9% were underage. 74% presented for fireworks-related injuries, 19% due to violent altercations.”

And then the deluge – details, details, details of diagnoses and symptoms: “Tinnitus, Hearing loss, Soft tissue injury, Nasal bone fracture, Perforation of the ear drum, Fracture of the midface, Bruised nose, Epistaxis (after trauma), Hyperacusis, Burn, Calvarian skull fracture, Intracerebral hemorrhage, Bent fixation of the patient’s epithesis.”

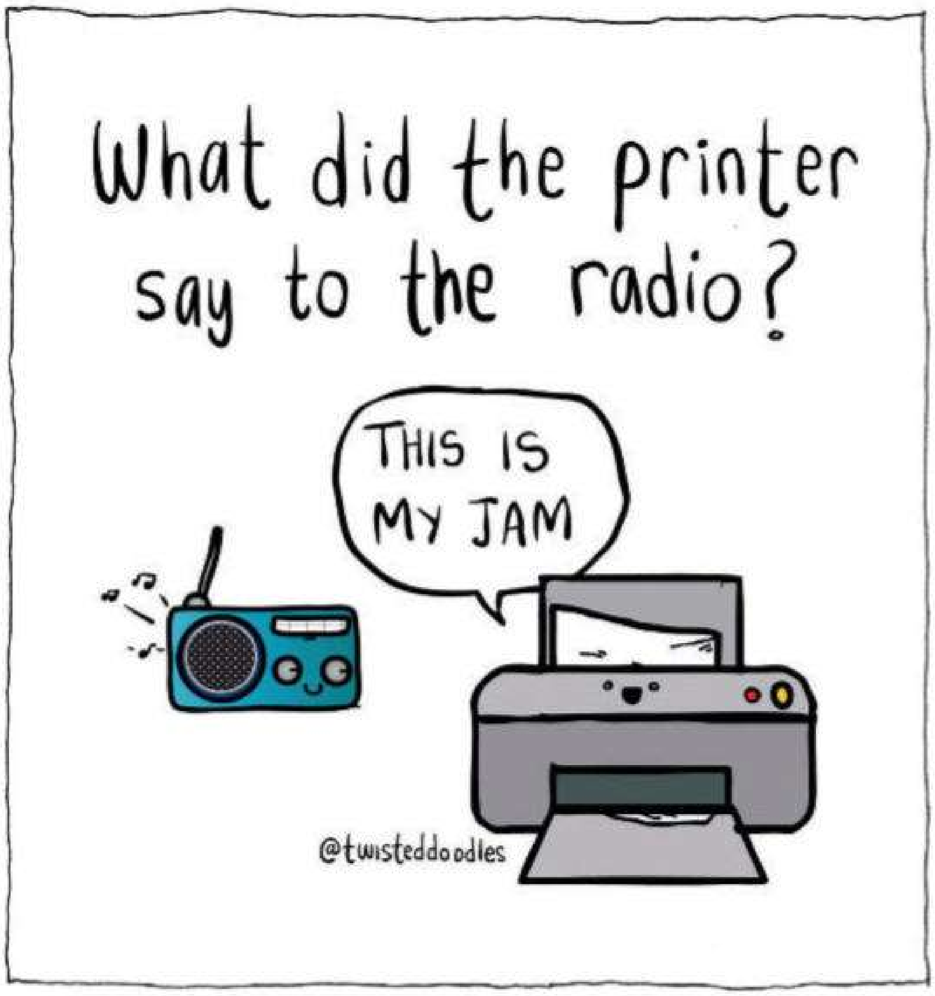
The covid-19 pandemic, burgeoning in 2020, put a damper on the activity. The low point came fairly early, a pitiful sparsity-bordering-on-absence for anyone who craves heaps of holiday-in-the-hospital pyrotechnic-related excitement. The turn of the year 2021/2022 had the fewest such patients, “with only one New Year’s Eve-associated emergency presentation, due to noise trauma caused by a scare gun”.

Wild geese chased

Wild geese in northern Europe – some of them – have a high time on New Year’s Eve.

Evidence for that appears in a study called “Wild goose chase: Geese flee high and far, and with aftereffects from New Year’s fireworks”. The facts, presented plainly, show what the geese were up to on those nights: “We analyzed GPS tracks of 347 wild migratory geese of four species during eight NYs quantifying the effects of fireworks on individuals. We show that, in parallel with particulate matter increases, during the night of NY geese flew on average 5–16 km further and 40–150 m higher, and more often shifted to new roost sites than on previous nights.”

Twisteddoodles *for New Scientist*


What did the printer say to the radio?
THIS IS MY JAM
@twisteddoodles

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or New Scientist, 9 Derry Street, London, W8 5HY
Consideration of items sent in the post will be delayed

Fish and arms

Feedback is entranced by the meanings of the title of the old book *Heraldry of Fish: Notices of the principal families bearing fish in their arms*.

Entranced also by the name of the book’s author, Thomas Moule. Moule is a near case of nominative determinism – his surname is the French word for the kind of shellfish English speakers call a mussel. But mussels, being bivalve molluscs, aren’t fish. And Moule, writing about fish, therefore may not be a pure case of nominative determinism. It’s a bit iffy. Maybe a red herring.

Which brings us back to the book title. Its very first word says the book is about heraldry. Heraldry deals notably with coats of arms. “Coat of arms” is itself a phrase that perplexes and delights young children, who know that their hands and arms go into the sleeves of the kind of coats that keep people warm in winter. The children learn, when omniscient adults explain down to them, that the term “coat of arms” usually isn’t about that kind of coat or that kind of arms.

But back to the title. Back to those “families bearing fish in their arms”. The words plainly say that those families all have family-identity symbols that include drawings of fish. But alternatively, and quite differently, the words plainly say that the people in those families often use their upper limbs to carry one or several cold-blooded, gilled, finned vertebrate animals.

Which meaning – drawings of fish, or actual smelly, floppy fish – did Moule intend?

The book contains many, many drawings of coats of arms. The way to answer this question is to study all the drawings in the book, to see whether they depict people carrying trout or cod or any other variety of fish (but maybe not shellfish). Feedback leaves it as a matter of delight to you, dear reader, to go see for yourself.

Heraldry of Fish: Notices of the principal families bearing fish in their arms, published in 1842 in London, is proof that a book more than a century and a half old can be capable of distracting the thoughts of anyone who chooses to pay too much attention to it.

Caller pre-ID

Anne Tener says she has an ability that should be added to Feedback’s list of trivial superpowers. She writes: “Well before the time of call display and often before the phone even rings, I know who is trying to contact me and sometimes, the nature of the call. This ‘power’ has often come in handy when I would prefer to avoid that particular contact at that moment!”

Is this superpower trivial? Triviality here can be measured by the total number of callers. If all incoming calls are from just one person, recognising who is calling is plainly trivial. In contrast, if a large number of people are phoning Anne, this recognition ability borders on the godlike.

Feedback also notes that Anne Tener, having superior reception clarity, is a case of nominative determinism. ▮

Marc Abrahams

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